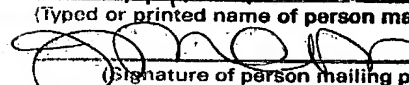


FOR (RE) (Modified) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER <b>GRP-0010</b>
<b>TRANSMITTAL LETTER TO THE UNITED STATES</b> <b>DESIGNATED/ELECTED OFFICE (DO/EO/US)</b> <b>CONCERNING A FILING UNDER 35 U.S.C. 371</b>		U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR) <b>10/049417</b>
INTERNATIONAL APPLICATION NO. <b>PCT/DK00/00443</b>	INTERNATIONAL FILING DATE <b>9 August 2000</b>	PRIORITY DATE CLAIMED <b>9 August 1999</b>
TITLE OF INVENTION <b>MULTI-CHANNEL PROCESSING METHOD</b>		
APPLICANT(S) FOR DO/EO/US <b>KIM RISHOJ PEDERSEN, ET AL.</b>		
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:		
<ol style="list-style-type: none"> <li>1. <input checked="" type="checkbox"/> This is a <b>FIRST</b> submission of items concerning a filing under 35 U.S.C. 371.</li> <li>2. <input type="checkbox"/> This is a <b>SECOND</b> or <b>SUBSEQUENT</b> submission of items concerning a filing under 35 U.S.C. 371.</li> <li>3. <input checked="" type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (24) indicated below.</li> <li>4. <input type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (Article 31).</li> <li>5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371 (c) (2))           <ol style="list-style-type: none"> <li>a. <input checked="" type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau).</li> <li>b. <input type="checkbox"/> has been communicated by the International Bureau.</li> <li>c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US).</li> </ol> </li> <li>6. <input type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).           <ol style="list-style-type: none"> <li>a. <input type="checkbox"/> is attached hereto.</li> <li>b. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4).</li> </ol> </li> <li>7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))           <ol style="list-style-type: none"> <li>a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau).</li> <li>b. <input type="checkbox"/> have been communicated by the International Bureau.</li> <li>c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired.</li> <li>d. <input type="checkbox"/> have not been made and will not be made.</li> </ol> </li> <li>8. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).</li> <li>9. <input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).</li> <li>10. <input type="checkbox"/> An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).</li> <li>11. <input type="checkbox"/> A copy of the International Preliminary Examination Report (PCT/IPEA/409).</li> <li>12. <input checked="" type="checkbox"/> A copy of the International Search Report (PCT/ISA/210).</li> </ol> <p><b>Items 13 to 20 below concern document(s) or information included:</b></p> <ol style="list-style-type: none"> <li>13. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98.</li> <li>14. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.</li> <li>15. <input checked="" type="checkbox"/> A <b>FIRST</b> preliminary amendment.</li> <li>16. <input type="checkbox"/> A <b>SECOND</b> or <b>SUBSEQUENT</b> preliminary amendment.</li> <li>17. <input type="checkbox"/> A substitute specification.</li> <li>18. <input type="checkbox"/> A change of power of attorney and/or address letter.</li> <li>19. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.</li> <li>20. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4).</li> <li>21. <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).</li> <li>22. <input checked="" type="checkbox"/> Certificate of Mailing by Express Mail</li> <li>23. <input type="checkbox"/> Other items or information:</li> </ol>		
<div style="text-align: right;"> <p>             "Express Mail" mailing label number              Date of Deposit <b>February 8, 2002</b>              I hereby certify that this paper or fee is being deposited              with the United States Postal Service "Express Mail              Post Office to Addressee" service under 37 CFR 1.10              on the date indicated above and is addressed to the              Commissioner of Patents and Trademarks, Washington,              DC 20231.           </p> <p> <b>EL91410963405</b>  <b>Jennifer Watson</b>              (Typed or printed name of person mailing paper or fee)                (Signature of person mailing paper or fee)           </p> </div>		

**GRP-0010**

**CALCULATIONS**     **PTO USE ONLY**

## Page 2 of 2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

IN RE APPLICATION OF: KIM RISHOJ PEDERSEN, ET AL.

FOR: MULTI CHANNEL PROCESSING METHOD

**PRELIMINARY AMENDMENT**

The Assistant Commissioner of  
Patents and Trademarks  
Washington, DC 20231

Dear Sir:

Prior to the Examiner acting in the above-referenced application, please preliminary amend the claims as follows:

**IN THE SPECIFICATION:**

Please insert the following paragraph on page 1, beneath the title of the invention:

**--Cross Reference to Related Applications**

This application is related to the commonly assigned application entitled "Signal Processing Unit" (Attorney Docket No. GRP-0011), filed concurrently herewith, which is incorporated herein by reference in its entirety.--

Please replace the first paragraph on page 1, with the following rewritten clean version:

**--Field of the invention**

The invention relates to a system for processing audio signals, and more particularly, to a system for processing audio signals to be modified in accordance with certain speaker arrangement to provide desirable sound effect to listeners.--

"Express Mail" mailing label number 291410963405

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I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231.

Jennifer Matson

(Typed or printed name of person mailing paper or fee)

(Signature of person mailing paper or fee)

Please delete the second paragraph (lines 7-14) on page 1.

Please replace the last paragraph on page 2 with the following rewritten version:

--The invention relates to an audio signal format comprising N components (d1, d2, d3, ... dN), each of the said components (d1, d2, d3, ... dN) representing a direction, said components preferably being uncorrelated.--

Please rewrite the fourth and fifth paragraphs on page 3 as follows:

--With respect to the N components (d1, d2, d3, ... dN), where N is at least 3, a further advantageous embodiment of the invention is obtained.

When N is at least 10, preferably at least 20, a further advantageous embodiment of the invention is obtained.--

Please rewrite the last paragraph on page 3 and the first paragraph on page 4 as follows:

--When, the said directions are three-dimensional directions, a further advantageous embodiment of the invention is obtained.

When establishing a three dimensional format, the possibility of establishing a three dimensional audio image is facilitated.--

Please rewrite the third through sixth paragraphs on page 4 as follows:

--When some or all of said directions are angled in relation to a common reference plane and where preferably all of said directions to one and the same side of the plane have been placed with approximately the same angle in relation to the common reference plane, a further advantageous embodiment of the invention is obtained.

When the directions are placed on both sides of the common reference plane, where some or all of said directions are angled in relation to the common reference plane and where



preferably all of said directions to one and the same side of the plane have been placed with approximately the same angle in relation to the common reference plane, a further advantageous embodiment of the invention is obtained.

When the angle of the directions on one side of the common reference plane and the angle of the directions on the other side of said plane are substantially equal, a further advantageous embodiment of the invention is obtained.

When the said directions are distributed among all possible directions, a further advantageous embodiment of the invention is obtained.--

Please rewrite the last paragraph on page 4, continuing onto page 5, as follows:

--When the said directions are distributed with a larger proportion of directions in areas with a relatively high density of sound signals than in areas with a relatively low proportion of sound signals, a further advantageous embodiment of the invention is obtained.--

Please rewrite the first, second, and third paragraphs on page 5 as follows:

--When the said directions are distributed with a larger proportion of directions in areas in which the human perception of sound signals is relatively sharp, e.g. in front of the head, a further advantageous embodiment of the invention is obtained.

When said signal is decomposed to a signal comprising N directional components and according to an audio signal format as taught herein, a further advantageous embodiment of the invention is obtained.

Moreover, the invention relates to a method of processing audio signals said signals comprising M sub-signals ( $s_1, s_2, s_3, \dots s_M$ ), each of the said sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) comprising N components ( $d_1, d_2, d_3, \dots d_N$ ), each of the said components ( $d_1, d_2, d_3, \dots d_N$ ) representing a direction; where the said sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) are added to form a sum-signal ( $\Sigma s$ ) comprising N components ( $\Sigma d_1, \Sigma d_2, \Sigma d_3, \dots \Sigma d_N$ ), each of the said components ( $\Sigma d_1, \Sigma d_2, \Sigma d_3, \dots \Sigma d_N$ ) representing a direction, each of the said components ( $\Sigma d_1, \Sigma d_2, \Sigma d_3, \dots \Sigma d_N$ ) being the sum of the said M sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) corresponding components ( $d_1, d_2, d_3, \dots d_N$ ).--

Please rewrite the second paragraph, beginning at line 11, on page 6 as follows:

--Moreover, the invention relates to a method of processing audio signals said signals comprising M sub-signals ( $s_1, s_2, s_3, \dots s_M$ ), each of the said sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) comprising N components ( $d_1, d_2, d_3, \dots d_N$ ), each of the said components ( $d_1, d_2, d_3, \dots d_N$ ) representing a direction; where said sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) are results of a room-simulation using room-simulators, preferably multi-directional room-simulators, where the said sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) are added to form a sum-signal ( $\Sigma s$ ) comprising N components ( $\Sigma d_1, \Sigma d_2, \Sigma d_3, \dots \Sigma d_N$ ), each of the said components ( $\Sigma d_1, \Sigma d_2, \Sigma d_3, \dots \Sigma d_N$ ) representing a direction, each of the said components ( $\Sigma d_1, \Sigma d_2, \Sigma d_3, \dots \Sigma d_N$ ) being the sum of the said M sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) corresponding components ( $d_1, d_2, d_3, \dots d_N$ ).--

Please rewrite the first paragraph on page 7 as follows:

--Moreover, the invention relates to a method of representing an audio signal (AS), said method comprising the step of establishing at least two directional signal components (M), said directional signal components (M) preferably being uncorrelated.--

Please rewrite the fifth paragraph, beginning at line 16, on page 8 as follows:

--When the said audio signal is a room processed signal, a further advantageous embodiment of the invention is obtained.--

Please rewrite the fourth paragraph, beginning at line 18, on page 9 as follows:

--When at least two audio signal (AS) the signals are combined into one signal by means of an adding, a further advantageous embodiment of the invention is obtained.--

Please rewrite the last paragraph on page 9, continuing onto page 10, as follows:

--Moreover, the invention relates to a method of decoding a number (M) of directional components into a, preferably lower, number (N) of directional components, said method comprising the step a transforming of the input directional components to a number N of output directional components, said input directional components representing a room simulated audio signal, said directional components being preferably uncorrelated.--

Please rewrite the second paragraph, beginning at line 13, on page 10 as follows:

--Moreover, the invention relates to a rendering system comprising at least one input for receiving a number (M) of directional components (DC), said rendering system comprising means for transforming the input directional components into a number (N) of output channels according to at least one rendering method stored in associated storing means (MSM).--

Please rewrite the third paragraph on page 11 as follows:

When at least one of the said methods implies a transforming according to a gain matrix, a further advantageous embodiment of the invention is obtained.

Please rewrite the fifth paragraph on page 11 as follows:

--When the said method stored in the said storing means may be exchanged by means of a suitable software transmitting and/or receiving interface, a further advantageous embodiment of the invention is obtained.--

Please rewrite the first paragraph on page 12 as follows:

--When the rendering system comprises a user interface adapted for selecting at least two different predefined rendering methods stored in said storing means, a further advantageous embodiment of the invention is obtained.--

Please rewrite the fourth paragraph on page 12 as follows:

--When said system comprising a set of output channel (OC) connectors of which the rendering method may define a subset of output channel connectors to be activated when applying the transforming defined by the said, a further advantageous embodiment of the invention is obtained.--

Please rewrite the last paragraph on page 12, continuing onto page 13, as follows:

--Moreover, the invention relates to a multi-channel data carrier, said data carrier comprising a number (M) of audio channels (M), at least two of said channels representing a directional signal with respect to a virtual listener/reference position (VLP).--

Please rewrite the last paragraph on page 13, continuing onto page 14, as follows:

--When the directional channels are established independently of a subsequent rendering, a further advantageous embodiment of the invention is obtained.--

Please rewrite the first, second, and third paragraphs on page 14 as follows:

--When the number of directional channels are at least eight, preferably at least twenty, a further advantageous embodiment of the invention is obtained.

When at least two of the directional channels are uncorrelated, a further advantageous embodiment of the invention has been obtained.

When at least two of the directional channel are stored at the data carrier in a compressed state, a further advantageous embodiment of the invention is obtained.--

Please replace the section heading before the first paragraph on page 15, with the following rewritten section heading:

**--Detailed Description of the Drawings.--**

Please replace the section heading before the first paragraph on page 16, with the following rewritten section heading:

**--Detailed Description of Preferred Embodiments.--**

IN THE CLAIMS:

Please replace claims 1-27 with the following rewritten clean versions:

1. (Amended) Audio signal format comprising N components, each of said N components representing a direction, said N components being uncorrelated.
2. (Amended) The audio signal format according to claim 1, wherein the number of said N components is at least three (3).
3. (Amended) The audio signal format according to claim 1, wherein the number of said N components is at least ten (10).
4. (Amended) The audio signal format according to claim 1, wherein the said directions are three-dimensional directions.

5. (Amended) The audio signal format according to claim 1, wherein said directions are angled in relation to a common reference plane and all of said directions to one side of the common reference plane have been placed with a substantially same angle in relation to the common reference plane.

6. (Amended) The audio signal format according to claim 1, wherein said directions are placed on both sides of a common reference plane, where said directions are angled in relation to the common reference plane and all of said directions to one side of the common reference plane have been placed with a substantially same angle in relation to the common reference plane.

7. (Amended) The audio signal format according to claim 5, wherein an angle of the directions on the one side of the common reference plane and an angle of the directions on the other side of said common reference plane are substantially equal.

8. (Amended) The audio signal format according to claim 1, wherein said directions are distributed among all directions.

9. (Amended) The audio signal format according to claim 1, wherein said directions are distributed with a larger proportion of directions in areas with a relatively high density of sound signals than in areas with a relatively low proportion of sound signals.

10. (Amended) The audio signal format according to claim 1, wherein said directions are distributed with a larger proportion of directions in areas in which human perception of sound signals is relatively sharp.

11. (Amended) A method of representing an audio signal, wherein said audio signal is decomposed to a signal comprising N directional components and according to an audio signal format comprising N components, each of said N components representing a direction, said N components being uncorrelated.

12. (Amended) A method of processing audio signals, wherein said audio signals comprising M sub-signals, each of the said M sub-signals comprising N components, each of said N components representing a direction;

wherein said M sub-signals are added to form a sum-signal comprising N sum-components, each of said sum-components representing a direction, each of said sum-components being a sum of said M sub-signals corresponding to said N components.

13. (Amended) A method of processing audio signals, said audio signals comprising M sub-signals, each of said M sub-signals comprising N components, each of said N components representing a direction;

wherein said M sub-signals are results of a room-simulation using room-simulators,

wherein said M sub-signals are added to form a sum-signal comprising N sum-components, each of said N sum-components representing a direction, each of said N sum-components being a sum of said M sub-signals corresponding to said N components.

14. (Amended) A method of representing an audio signal, comprising the step of establishing at least two directional signal components, said directional signal components being uncorrelated.

15. (Amended) The method of representing an audio signal according to claim 14, wherein said audio signal is a room processed signal.

16. (Amended) The method according to claim 14, further comprising combining signals established by said method of representing an audio signal, wherein at least two audio signals are combined into one signal by means of an adding.

17. (Amended) A method of decoding M directional components into N directional components, comprising transforming M input directional components to N output directional components, said M input directional components representing a room simulated audio signal, said M input directional components being uncorrelated.



18. (Amended) A rendering system comprising:  
at least one input for receiving M directional components; and  
means for transforming said M input directional components into N output  
channels according to at least one rendering method stored in associated storing means.
19. (Amended) The rendering system according to claim 18, wherein said means  
for transforming includes a gain matrix.
20. (Amended) The rendering system according to claim 18, wherein said at least  
one rendering method stored in said storing means is exchanged by means of a suitable  
software transmitting and/or receiving interface.
21. (Amended) The rendering system according to claim 18, further comprising a  
user interface adapted for selecting at least two different predefined rendering methods  
stored in said storing means.
22. (Amended) The rendering system according to claim 18, further comprising a  
set of output channel connectors of which the rendering method defines a subset of output  
channel connectors to be activated when applying the transforming of said M input  
directional components into N output channels.

23. (Amended) A multi-channel data carrier, comprising a plurality of audio channels, at least two of said audio channels representing a directional signal with respect to a virtual listener/reference position.

24. (Amended) The multi-channel data carrier according to claim 23, wherein the audio channels are established independently of a subsequent rendering system.

25. (Amended) The multi-channel data carrier according to claim 23, wherein the number of said audio channels is at least eight (8).

26. (Amended) The multi-channel data carrier according to claim 23, wherein said at least two of the audio channels are uncorrelated.

27. (Amended) The multi-channel data carrier according to claim 23, wherein said at least two of the audio channels are stored at the data carrier in a compressed state.

Please add the following new claims 28 and 29:

28. (New) The audio signal format according to claim 1, wherein the number of said N components is at least twenty (20).

29. (New) The multi-channel data carrier according to claim 23, wherein the number of said audio channels is at least twenty (20).

IN THE ABSTRACT:

Please replace the abstract with the following rewritten clean version:

**Abstract of the Disclosure**

The invention relates to a method of processing audio signals which include M sub-signals, each of the M sub-signals having N components, each of the N components representing a direction. The M sub-signals are results of a room-simulation using room-simulators, wherein the M sub-signals are added to form a sum-signal including N sum-components, each of the N sum-components representing a direction, each of the N sum-components being a sum of the M sub-signals corresponding to the N components.

**REMARKS**

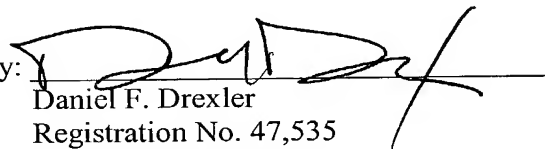
Applicants request entry of the above-identified amendments which conform the claims to U.S. practice. No new matter is being introduced by this Amendment as antecedent support is set forth in the specification and the original claims.

Prosecution on the merits is respectfully requested.

If there are any charges with respect to this Amendment or otherwise, please charge them to Deposit Account No. 06-1130 maintained by Applicants' attorneys.

Respectfully submitted,  
KIM RISHOJ PEDERSEN, ET AL.

CANTOR COLBURN LLP  
Applicants' Attorney

By:   
Daniel F. Drexler  
Registration No. 47,535  
Customer No. 23413

Date: 08 February 2002  
Telephone: 860-286-2929

**VERSION WITH MARKINGS TO SHOW CHANGES MADE**

IN THE SPECIFICATION:

Please amend the first paragraph on page 1 as follows:

**“Field of the invention**

The invention relates to a [format of] system for processing audio signals, [according to claim 1] and more particularly, to a [method of] system for processing audio signals [according to claim 9] to be modified in accordance with certain speaker arrangement to provide desirable sound effect to listeners.”

Please amend the last paragraph on page 2 as follows:

“The invention relates to an audio signal format comprising [

]N components (d1, d2, d3, ... dN)[ according to claim 1], [

]each of the said components (d1, d2, d3, ... dN) representing a direction, said components preferably being uncorrelated.”

Please amend the fourth and fifth paragraphs on page 3 as follows:

“[When, as stated in claim 2,]With respect to the N components (d1, d2, d3, ... dN), where N is at least 3, a further advantageous embodiment of the invention [has been]is obtained. .

When[, as stated in claim 3,] N is at least 10, preferably at least 20, a further advantageous embodiment of the invention [has been]is obtained.

Please amend the last paragraph on page 3 and the first paragraph on page 4 as follows:

“When, [as stated in claim 4,] the said directions are three-dimensional directions, a further advantageous embodiment of the invention [has been]is obtained.”

When establishing a three dimensional format, the possibility of establishing a three dimensional audio image [has been]is facilitated.”

Please amend the third through sixth paragraphs on page 4 as follows:

“When[, as stated in claim 5,] some or all of said directions are angled in relation to a common reference plane and where preferably all of said directions to one and the same side of the plane have been placed with approximately the same angle in relation to the common reference plane, a further advantageous embodiment of the invention [has been]is obtained.

When[, as stated in claim 6,] the directions are placed on both sides of the common reference plane, where some or all of said directions are angled in relation to the common reference plane and where preferably all of said directions to one and the same side of the plane have been placed with approximately the same angle in relation to the common reference plane, a further advantageous embodiment of the invention [has been]is obtained.

When[, as stated in claim 7,] the angle of the directions on one side of the common reference plane and the angle of the directions on the other side of said plane are substantially equal, a further advantageous embodiment of the invention [has been]is obtained.

When[, as stated in claim 8,] the said directions are distributed among all possible directions, a further advantageous embodiment of the invention [has been]is obtained.”

Please amend the last paragraph on page 4, continuing onto page 5, as follows:

“When[, as stated in claim 9,] the said directions are distributed with a larger proportion of directions in areas with a relatively high density of sound signals than in areas with a relatively low proportion of sound signals, a further advantageous embodiment of the invention [has been]is obtained.”

Please amend the first, second, and third paragraphs on page 5 as follows:

“When[, as stated in claim 10,] the said directions are distributed with a larger proportion of directions in areas in which the human perception of sound signals is relatively sharp, e.g. in front of the head, a further advantageous embodiment of the invention [has been]is obtained.

When[, as stated in claim 11,] said signal is decomposed to a signal comprising N directional components and according to an audio signal format as taught herein[characterized in one or more of claims 1 – 10], a further advantageous embodiment of the invention [has been]is obtained.

Moreover, the invention relates to a method of processing audio signals[ according to claim 12], [

]said signals comprising [

]M sub-signals (s1, s2, s3, ... sM), [

]each of the said sub-signals (s1, s2, s3, ... sM) comprising [

]N components (d1, d2, d3, ... dN), [

]each of the said components (d1, d2, d3, ... dN) representing a direction; [

]where the said sub-signals (s1, s2, s3, ... sM) are added to form a sum-signal ( $\Sigma s$ ) comprising [





]each of the said components ( $\Sigma d_1, \Sigma d_2, \Sigma d_3, \dots \Sigma d_N$ ) being the sum of the said M sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) corresponding components ( $d_1, d_2, d_3, \dots d_N$ ).”

Please amend the first paragraph on page 7 as follows:

“Moreover, the invention relates to a method of representing an audio signal (AS), said method [according to claim 14, ]comprising the step of [

]establishing at least two directional signal components (M), said directional signal components (M) preferably being uncorrelated.”

Please amend the fifth paragraph, beginning at line 16, on page 8 as follows:

“When[, as stated in claim 15,] the said audio signal is a room processed signal, a further advantageous embodiment of the invention [has been]is obtained.”

Please amend the fourth paragraph, beginning at line 18, on page 9 as follows:

“When[, as stated in claim 16,] at least two audio signal (AS) the signals are combined into one signal by means of an adding, a further advantageous embodiment of the invention [has been]is obtained.”

Please amend the last paragraph on page 9, continuing onto page 10, as follows:

“Moreover, the invention relates to a method of decoding a number (M) of directional components into a, preferably lower, number (N) of directional components[ according to claim 17], said method comprising the step a transforming of the input directional components to a number N of output directional components, said input directional components representing a room simulated audio signal, said directional components being preferably uncorrelated.”

Please amend the second paragraph, beginning at line 13, on page 10 as follows:

“Moreover, the invention relates to a rendering system comprising at least one input for receiving a number (M) of directional components (DC)[ according to claim 18], said

rendering system comprising means for transforming the input directional components into a number (N) of output channels according to at least one rendering method stored in associated storing means (MSM).”

Please amend the third paragraph on page 11 as follows:

“When[, as stated in claim 19,] at least one of the said methods implies a transforming according to a gain matrix, a further advantageous embodiment of the invention [has been]is obtained.”

Please amend the fifth paragraph on page 11 as follows:

“When[, as stated in claim 20,] the said method stored in the said storing means may be exchanged by means of a suitable software transmitting and/or receiving interface, a further advantageous embodiment of the invention [has been]is obtained.”

Please amend the first paragraph on page 12 as follows:

“When[, as stated in claim 21,] the rendering system comprises a user interface adapted for selecting at least two different predefined rendering methods stored in said storing means, a further advantageous embodiment of the invention [has been]is obtained.”

Please amend the fourth paragraph on page 12 as follows:

“When[, as stated in claim 22,] said system comprising a set of output channel (OC) connectors of which the rendering method may define a subset of output channel connectors to be activated when applying the transforming defined by the said, a further advantageous embodiment of the invention [has been]is obtained.”

Please amend the last paragraph on page 12, continuing onto page 13, as follows:

“Moreover, the invention relates to a multi-channel data carrier[ according to claim 23], said data carrier comprising a number (M) of audio channels (M), at least two of said channels representing a directional signal with respect to a virtual listener/reference position (VLP).”

Please amend the last paragraph on page 13, continuing onto page 14, as follows:  
“When[, as stated in claim 24,] the directional channels are established independently of a subsequent rendering, a further advantageous embodiment of the invention [has been]is obtained.”

Please amend the first, second, and third paragraphs on page 14 as follows:  
“When[, as stated in claim 25,] the number of directional channels are at least eight, preferably at least twenty, a further advantageous embodiment of the invention [has been]is obtained.”

When[, as stated in claim 26,] at least two of the directional channels are uncorrelated, a further advantageous embodiment of the invention has been obtained.

When[, as stated in claim 27,] at least two of the directional channel are stored at the data carrier in a compressed state, a further advantageous embodiment of the invention [has been]is obtained.”

Please amend the section heading before the first paragraph on page 15 as follows:

“[The figures] **Detailed Description of the Drawings**”

Please amend the section heading before the first paragraph on page 16 as follows:

“Detailed [description] **Description of Preferred Embodiments**”

#### **CLAIM AMENDMENTS**

Please amend claims 1-27 as follows:

1. (Amended) Audio signal format comprising N components, [(d1, d2, d3, ... dN),] each of [the] said N components [(d1, d2, d3, ... dN)] representing a direction, said N components [preferably] being uncorrelated.

2. (Amended) [Audio] The audio signal format according to claim 1, [comprising] wherein the number of said N components [(d1, d2, d3, ... dN), where N] is at least [3] three (3).

3. (Amended) [Audio] The audio signal format according to claim 1, [or 2 comprising] wherein the number of said N components [(d1, d2, d3, ... dN), where N] is at least [10, preferably at least 20] ten (10).

4. (Amended) [Audio] The audio signal format according to claim 1[-3], wherein the said directions are three-dimensional directions.

5. (Amended) [Audio] The audio signal format according to claim 1[-4], wherein [some or all of] said directions are angled in relation to a common reference plane and [where preferably] all of said directions to one [and the same ]side of the common reference plane have been placed with [approximately the] a substantially same angle in relation to the common reference plane.

6. (Amended) [Audio] The audio signal format according to claim 1[-5], wherein said directions are placed on both sides of [the] a common reference plane, where [some

or all of] said directions are angled in relation to the common reference plane and [where preferably] all of said directions to one [and the same ]side of the common reference plane have been placed with [approximately the] a substantially same angle in relation to the common reference plane.

7. (Amended) [Audio] The audio signal format according to claim [1-6] 5, wherein [the] an angle of the directions on the one side of the common reference plane and [the] an angle of the directions on the other side of said common reference plane are substantially equal.

8. (Amended) [Audio] The audio signal format according to [one or more of claims 1 – 7] claim 1, wherein [the] said directions are distributed among all [possible] directions.

9. (Amended) [Audio] The audio signal format according to [claims 1-8] claim 1, wherein [the] said directions are distributed with a larger proportion of directions in areas with a relatively high density of sound signals than in areas with a relatively low proportion of sound signals.

10. (Amended) [Audio] The audio signal format according to claim 1[-8], wherein [the] said directions are distributed with a larger proportion of directions in areas in which [the] human perception of sound signals is relatively sharp[, e.g. in front of the head].

11. (Amended) [Method] A method of representing an audio signal, wherein said audio signal is decomposed to a signal comprising N directional components and according to an audio signal format [as characterized in one or more of claims 1 – 10] comprising N components, each of said N components representing a direction, said N components being uncorrelated.

12. (Amended) [Method] A method of processing audio signals, wherein said audio signals comprising M sub-signals [(s1, s2, s3, ... sM)], each of the said M sub-signals [(s1, s2, s3, ... sM)] comprising N components [(d1, d2, d3, ... dN)], each of [the] said N components [(d1, d2, d3, ... dN)] representing a direction;

[where the] wherein said M sub-signals [(s1, s2, s3, ... sM)] are added to form a sum-signal [(Σs)] comprising N [components (Σd1, Σd2, Σd3, ... ΣdN)] sum-components, each of [the] said [components (Σd1, Σd2, Σd3, ... ΣdN)] sum-components representing a direction, each of [the] said [components (Σd1, Σd2, Σd3, ... ΣdN)] sum-components being [the] a sum of [the] said M sub-signals [(s1, s2, s3, ... sM)] corresponding to said N components [(d1, d2, d3, ... dN)].

13. (Amended) [Method] A method of processing audio signals, said audio signals comprising M sub-signals [(s1, s2, s3, ... sM)], each of [the] said M sub-signals [(s1, s2, s3, ... sM)] comprising N components [(d1, d2, d3, ... dN)], each of [the] said N components [(d1, d2, d3, ... dN)] representing a direction;

[where] wherein said M sub-signals [(s1, s2, s3, .. sM)] are results of a room-simulation using room-simulators, [preferably multi-directional room-simulators,]

[where the] wherein said M sub-signals [(s1, s2, s3, ... sM)] are added to form a sum-signal [(Σs)] comprising N [components (Σd1, Σd2, Σd3, ... ΣdN)] sum-components, each of [the] said [components (Σd1, Σd2, Σd3, ... ΣdN)] N sum-components representing a direction, each of [the] said [components (Σd1, Σd2, Σd3, ... ΣdN)] N sum-components being [the] a sum of [the] said M sub-signals [(s1, s2, s3, ... sM)] corresponding to said N components [(d1, d2, d3, ... dN)].

14. (Amended) [Method] A method of representing an audio signal, [(AS), said method] comprising the step of establishing at least two directional signal components [(M)], said directional signal components [(M) preferably] being uncorrelated.

15. (Amended) [Method] The method of representing an audio signal according to claim 14, [whereby the] wherein said audio signal is a room processed signal.

16. (Amended) [Method of combining signals established according to the] The method according to claim 14 [and 15], [whereby] further comprising combining signals established by said method of representing an audio signal, wherein at least two audio signals [(AS)] are combined into one signal by means of an adding.

17. (Amended) [Method] A method of decoding [a number (M) of] M directional components into [a, preferably lower, number (N) of] N directional components, [said

method] comprising [the step a] transforming [of the] M input directional components to [a number] N [of] output directional components, said M input directional components representing a room simulated audio signal, said M input directional components being [preferably] uncorrelated.

18. (Amended) [Rendering] A rendering system comprising:  
 at least one input for receiving [a number (M) of] M directional components;  
 [(DC), said rendering system comprising] and  
 means for transforming [the] said M input directional components into [a number (N) of] N output channels according to at least one rendering method stored in associated storing means [(MSM)].

19. (Amended) [Rendering] The rendering system according to claim 18, wherein  
 [one at least of the] said [methods implies a] means for transforming [according to]  
includes a gain matrix.

20. (Amended) [Rendering] The rendering system according to claim 18 [or 19],  
 wherein [the] said at least one rendering method stored in [the] said storing means [may  
 be] is exchanged by means of a suitable software transmitting and/or receiving interface.

21. (Amended) [Rendering] The rendering system according to [claims 18-20]  
claim 18, [wherein the rendering system comprises] further comprising a user interface



adapted for selecting at least two different predefined rendering methods stored in said storing means.

22. (Amended) [Rendering] The rendering system according to [claims 18-21] claim 18, [wherein said system] further comprising a set of output channel [(OC)] connectors of which the rendering method [may define] defines a subset of output channel connectors to be activated when applying the transforming [defined by the said] of said M input directional components into N output channels.

23. (Amended) [Multi-channel] A multi-channel data carrier, [said data carrier] comprising a [number (M)] plurality of audio channels [(M)], at least two of said audio channels representing a directional signal with respect to a virtual listener/reference position [(VLP)].

24. (Amended) [Multi-channel] The multi-channel data carrier according to claim 23, wherein the [directional] audio channels are established independently of a subsequent rendering system.

25. (Amended) [Multi-channel] The multi-channel data carrier according to claim 23 [or 24], wherein the number of [directional] said audio channels [are] is at least eight[, preferably at least twenty] (8).

26. (Amended) [Multi-channel] The multi-channel data carrier according to claim 23[-25], wherein said at least two of the [directional] audio channels are uncorrelated.

27. (Amended) [Multi-channel] The multi-channel data carrier according to claim 23[-26], wherein said at least two of the [directional channel] audio channels are stored at the data carrier in a compressed state.

# ABSTRACT AMENDMENTS

Please amend the Abstract as follows:

## [Abstract] Abstract of the Disclosure

The invention relates to [an audio signal format comprising N components (d1, d2, d3, ... dN), each of the said components (d1, d2, d3, ... dN) representing a direction. According to a preferred embodiment of the invention, the components should preferably be uncorrelated to the extent that no panning is established between the signals contained in the format] a method of processing audio signals which include M sub-signals, each of the M sub-signals having N components, each of the N components representing a direction. The M sub-signals are results of a room-simulation using room-simulators, wherein the M sub-signals are added to form a sum-signal including N sum-components, each of the N sum-components representing a direction, each of the N sum-components being a sum of the M sub-signals corresponding to the N components.

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## MULTI CHANNEL PROCESSING METHOD

### Field of the invention

The invention relates to a format of audio signals according to claim 1 and a method of processing audio signals according to claim 9.

5

Moreover, the invention relates to a method of processing audio signals according to claim 12, a method of processing audio signals according to claim 13, a method of representing an audio signal (AS), said method according to claim 14, a  
10 method of decoding a number (M) of directional components () into a, preferably lower, number (N) of directional components according to claim 17, a rendering system comprising at least one input for receiving a number (M) of directional components (DC) according to claim 18 and a multi-channel data carrier according to claim 23

15

### Background of the invention

Audio processing and audio rendering are well-known within the art.

An audio rendering system may typically imply a sound generating unit, e.g. a CD or  
20 DVD player and an associated amplifier and loudspeaker system.

A problem of the rendering known within the art is that the systems are inflexible with respect to a possible desired changing of the rendering method. Thus, a change from e.g. a two channel stereo rendering into a five channel cinema rendering will  
25 typically infer serious technical problems, and the quality of an obtainable rendering may be questioned.

However the number of outputs and the preferred final speaker arrangement most often determines how the input signals are being processed, as it is imperative that  
30 the sound is modified according to that certain speaker arrangement for the sound engineer to give the listener the desired experience.

Consequently sound reproduction is very constrained by the fact that it is necessary almost from the beginning to the end of the process to consider which sound format and speaker arrangement will be used eventually. And thereby lots of opportunities and properties of the sound are lost almost from the start.

5

One of the consequences is that true reverberation or room simulation is almost impossible to achieve by prior art audio formats.

Another aspect is, that having more sound reproduction formats, including  
10 stereophonic formats, surround sound formats and future multi-channel formats, it is necessary to record and process the sound differently according to each reproduction format.

Preferably there would be some method to record, modify and mix the input signals  
15 without having to consider which reproduction format to use. Then all the heavy and significant work on the input signals could be done once, no matter what equipment the eventual listener intends to use.

It is one object of the invention to provide a method for multi-channel sound  
20 processing where it is unnecessary to possess knowledge of the final sound reproduction format.

### **Summary of the invention**

25 The invention relates to an audio signal format comprising

N components ( $d_1, d_2, d_3, \dots, d_N$ ) according to claim 1,

each of the said components ( $d_1, d_2, d_3, \dots, d_N$ ) representing a direction, said  
30 components preferably being uncorrelated.

A component may comprise an accumulation of zero or more signals in a direction defined by said component.

5 According to a preferred embodiment of the invention, the components should preferably be uncorrelated. At least to the extent that no panning or dependency is established between the signals contained in the format.

10 It should be noted, that the signal format according to the invention may be supplemented by further signal components or signal representations within the scope of the invention.

When, as stated in claim 2, N components ( $d_1, d_2, d_3, \dots d_N$ ), where N is at least 3, a further advantageous embodiment of the invention has been obtained.

15 When, as stated in claim 3, N is at least 10, preferably at least 20, a further advantageous embodiment of the invention has been obtained.

20 According to the invention, experiments have shown that impressive rendering methods may relatively easy be applied to audio signals represented in the format according to the invention when increasing the number of signal components.

Accordingly, experiments have shown that a ten-directional format ( $N = 10$ ) may be rendered into an impressing stereo image, e.g. by means of a simple gain matrix mapping the direction components into the channels of a stereo rendering system.  
25 Moreover, an increase of the number of directional components have proven to be advantageous when dealing with multi-channel rendering, such as five channel rendering.

30 When, as stated in claim 4, the said directions are three-dimensional directions, a further advantageous embodiment of the invention has been obtained.

When establishing a three dimensional format, the possibility of establishing a three dimensional audio image has been facilitated.

5 Evidently, the three dimensional signal format may include both true signal components or even "trick"-components.

When, as stated in claim 5, some or all of said directions are angled in relation to a common reference plane and where preferably all of said directions to one and the same side of the plane have been placed with approximately the same angle in  
10 relation to the common reference plane, a further advantageous embodiment of the invention has been obtained.

When, as stated in claim 6, the directions are placed on both sides of the common reference plane, where some or all of said directions are angled in relation to the  
15 common reference plane and where preferably all of said directions to one and the same side of the plane have been placed with approximately the same angle in relation to the common reference plane, a further advantageous embodiment of the invention has been obtained.

20 When, as stated in claim 7, the angle of the directions on one side of the common reference plane and the angle of the directions on the other side of said plane are substantially equal, a further advantageous embodiment of the invention has been obtained.

25 When, as stated in claim 8, the said directions are distributed among all possible directions, a further advantageous embodiment of the invention has been obtained.

According to the invention, an experience-based allocation of directions of components may be applied.

30

When, as stated in claim 9, the said directions are distributed with a larger proportion of directions in areas with a relatively high density of sound signals than in areas

with a relatively low proportion of sound signals, a further advantageous embodiment of the invention has been obtained.

When, as stated in claim 10, the said directions are distributed with a larger  
5 proportion of directions in areas in which the human perception of sound signals is relatively sharp, e.g. in front of the head, a further advantageous embodiment of the invention has been obtained..

When, as stated in claim 11, said signal is decomposed to a signal comprising N  
10 directional components and according to an audio signal format as characterized in one or more of claims 1 – 10, a further advantageous embodiment of the invention has been obtained.

Moreover, the invention relates to a method of processing audio signals according to  
15 claim 12,

said signals comprising

M sub-signals ( $s_1, s_2, s_3, \dots s_M$ ),  
20

each of the said sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) comprising

N components ( $d_1, d_2, d_3, \dots d_N$ ),

25 each of the said components ( $d_1, d_2, d_3, \dots d_N$ ) representing a direction;

where the said sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) are added to form a sum-signal ( $\Sigma s$ ) comprising

30 N components ( $\Sigma d_1, \Sigma d_2, \Sigma d_3, \dots \Sigma d_N$ ),

each of the said components ( $\Sigma d_1, \Sigma d_2, \Sigma d_3, \dots \Sigma d_N$ ) representing a direction,

each of the said components ( $\Sigma d_1, \Sigma d_2, \Sigma d_3, \dots \Sigma d_N$ ) being the sum of the said M sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) corresponding components ( $d_1, d_2, d_3, \dots d_N$ ).

5

According to the invention, the format may advantageously be applied as an intermediate signal processing format and e.g. different sound sources represented according to the same format may be superpositioned by a simple adding of the signal components.

10

Moreover, the invention relates to a method of processing audio signals according to claim 13,

said signals comprising

15

M sub-signals ( $s_1, s_2, s_3, \dots s_M$ ),

each of the said sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) comprising

20

N components ( $d_1, d_2, d_3, \dots d_N$ ),

each of the said components ( $d_1, d_2, d_3, \dots d_N$ ) representing a direction;

where said sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) are results of a room-simulation using room-simulators, preferably multi-directional room-simulators,

25

where the said sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) are added to form a sum-signal ( $\Sigma s$ ) comprising

30

N components ( $\Sigma d_1, \Sigma d_2, \Sigma d_3, \dots \Sigma d_N$ ),

each of the said components ( $\Sigma d_1, \Sigma d_2, \Sigma d_3, \dots \Sigma d_N$ ) representing a direction,



each of the said components ( $\Sigma d_1, \Sigma d_2, \Sigma d_3, \dots \Sigma d_N$ ) being the sum of the said M sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) corresponding components ( $d_1, d_2, d_3, \dots d_N$ ).

- 5 Moreover, the invention relates to a method of representing an audio signal (AS), said method according to claim 14, comprising the step of

establishing at least two directional signal components (M), said directional signal components (M) preferably being uncorrelated.

10

The audio signal may subsequently be decoded into a desired rendering format, such as five channel.

- 15 Basically, the audio format represents a flexible audio coding in the sense, that the audio-signals may be encoded without any knowledge about the rendering system.

It should be noted that the method according to the invention implies a very advantageous representation of a signal due to the fact that the final rendering of the  
20 signal may be performed strictly according to a simple mapping if so desired, e.g. a gain matrix, still maintaining the intended total signal image. The final rendering may thus, if desired, be performed solely with focus on the rendering of a signal component having a certain direction parameter and without differentiating between the different signals and the type of the signals contained in the directional signal  
25 component. In other words, direct sound and subsequent room simulated signal may be rendered in the same way.

Accordingly, a music mix may be established once and for all in the format  
30 according to the invention, and subsequently, when new formats appear on the commercial market, a rendering may be established on the basis of the said format.

According to the invention, the term uncorrelated signal components implies that different directional signal components are independent in a degree that a subsequent rendering in a rendering system is possible without compensating for mutual dependencies between different directional signal components.

5

According to the invention, the signal components may be subsequently be rendered in almost every possible audio rendering system, e.g. stereo, five channel surround sound, without considering the originally intended rendering method.

10 A component includes an accumulation of zero or more signals in a direction defined by said component.

Typically, the method according to the invention may be performed without any (or very little) knowledge of the downstream rendering system.

15

When, as stated in claim 15, the said audio signal is a room processed signal, a further advantageous embodiment of the invention has been obtained.

Again, the term uncorrelated signal components implies that the signal components  
20 are independent. An independency between the signals of different directional signal components of a room simulated signal may specifically imply that signals representing a direct sound signal of a room signal should be independent with other direct sound representing signals of other directional signal components. Evidently, when dealing with a room simulated signal, a correlation between signals of  
25 different signal components will occur within the scope of the invention, due to the fact that a room simulation of a direct sound signal will likely produce a subsequent reverberation sound signal bundle distributed in different signal directional components (generally).

30 It should be noted that the method according to the invention implies a very advantageous representation of a signal when dealing with room processed signals due to the fact that the final rendering of the room simulated signal may be

performed strictly according to a simple mapping if so desired, e.g. a gain matrix, still maintaining the intended total signal image. The final rendering may thus, if desired, be performed solely with focus on the rendering of a signal component having a certain direction parameter and without differentiating between the different  
5 signals and the type of the signals contained in the directional signal component. In other words, direct sound and subsequent room simulated signal may be rendered in the same way.

This unique feature implies e.g. that a music recording may be mixed, room  
10 processed, etc. by a sound engineer and encoded/stored according to the invention.

The recording may then be transformed into a signal standard fitting to a certain desired rendering method, e.g. stereo.

15 Subsequently, the stored music recording may be redistributed in another format without re-mixing the music recording.

When, as stated in claim 16, at least two audio signal (AS) the signals are combined into one signal by means of an adding, a further advantageous embodiment of the  
20 invention has been obtained.

According to the invention, an adding of signal components would preferably involve the signals (in time) of the same signal directional component of two different audio signals are summed.

25

Clearly, according to the invention, the format and the method facilitate a modular approach according to which e.g. the room processing may be processed independently.

30 Moreover, the invention relates to a method of decoding a number (M) of directional components into a, preferably lower, number (N) of directional components

according to claim 17, said method comprising the step a transforming of the input directional components to a number N of output directional components, said input directional components representing a room simulated audio signal, said directional components being preferably uncorrelated.

5

The method of decoding the above signal, which may also be regarded as a rendering, has proved to be very efficient and effective, due to the fact that the rendering itself may be performed by means of simple signal processing if desired.

Hence, a rendering of the directional components into an X-channel signal (X: more  
10 or less arbitrary) may be performed by means of a simple gain matrix mapping the M  
directional components into the X number of channels.

Moreover, the invention relates to a rendering system comprising at least one input for receiving a number (M) of directional components (DC) according to claim 18, 15 said rendering system comprising means for transforming the input directional components into a number (N) of output channels according to at least one rendering method stored in associated storing means (MSM).

According to a preferred embodiment of the invention, the rendering system should  
20 be able to be re-configured, e.g. by means of software.

According to a preferred embodiment of the invention M should be significantly higher than N.

25 The rendering system according to the invention represents a very flexible down-  
stream rendering in the sense that the signal may be completely pre-established  
previous to the rendering, thereby reducing the task of the rendering system to be a  
mapping.

30 Another advantageous feature is that the rendering system may be specifically designed to fit to the room (and e.g. amplifier and loudspeaker) in which the sound has to be reproduced.

According to a preferred embodiment of the invention, a unique spatial relation exists between each input signal component and the intended location of an output channel of a rendering system.

5

According to the invention, the means for transforming the input directional components into a number (N) of output channels may perform a signal processing based on a simple gain matrix mapping of the signal components into the said output signals. Evidently, the means for transforming the input directional components into  
10 a number (N) of output channels may also additionally apply other signal processing methods, such as delay compensation for compensating the positioning of the loudspeakers of the rendering system, a compression applied for adapting the rendered output signal to noisy environments, e.g. a cabin of a car.

15 When, as stated in claim 19, at least one of the said methods implies a transforming according to a gain matrix, a further advantageous embodiment of the invention has been obtained.

According to the present embodiment of the invention, the required signal processing  
20 to be performed in the rendering system may be minimized.

When, as stated in claim 20, the said method stored in the said storing means may be exchanged by means of a suitable software transmitting and/or receiving interface, a further advantageous embodiment of the invention has been obtained.

25

According to the present embodiment, the rendering methods may be downloaded into the rendering system, e.g. by means of an IRDA port, a traditional RJ 45 signal interface, etc. Another way may also be that of incorporating the method defining software on a DVD or a CD.

30

It should be noted that the bandwidth required for the transmittal of method defining software into the rendering may typically be relatively small.

When, as stated in claim 21, the rendering system comprises a user interface adapted for selecting at least two different predefined rendering methods stored in said storing means, a further advantageous embodiment of the invention has been  
5 obtained.

According to the invention, a user may adapt his rendering system, to the room in which music (or speech) is to be reproduced by simply switching between different predefined methods. Evidently, the rendering system should comprise the amplifier  
10 and associated loudspeakers of the rendering system.

The rendering system may e.g. comprise a set of predefined rendering methods associated with stereo reproduction, a set of predefined rendering methods associated with five channel rendering, etc.

15

When, as stated in claim 22, said system comprising a set of output channel (OC) connectors of which the rendering method may define a subset of output channel connectors to be activated when applying the transforming defined by the said, a further advantageous embodiment of the invention has been obtained.

20

According to the invention, a rendering system may feed a traditional amplifier/loud speaker setup (e.g. a stereo setup) by means of two rendering method defined output channel connectors if so desired. Moreover, the same system may moreover feed another type of rendering system via other method defined output channel

25 connectors.

Accordingly, the rendering system according to the invention may comprises e.g. a DVD reading unit and a unit adapted for allocating the directional signal read by the DVD into a kind of crossfield output connectors.

30

Moreover, the invention relates to a multi-channel data carrier according to claim 23, said data carrier comprising a number (M) of audio channels (M), at least two of said

channels representing a directional signal with respect to a virtual listener/reference position (VLP).

According to the above stated embodiment of the invention, an advantageous  
5 rendering of a multi-channel directional audio signal stored at the carrier may be obtained. Experiments have shown that subsequent rendering of the signal into e.g. a multi-channel rendering system, not necessarily predefined at the time of storing the audio-signal at the data carrier, may facilitate a relatively simple, and even more important high quality rendering. Experiments have shown, that the signal format  
10 e.g. facilitate a convincing rendering of the preprocessed room simulation.

A further advantageous feature of the invention is that the bandwidth may be kept constant irrespective of the character of the stored audio signal, the number of sources, etc.

15 According to a preferred embodiment of the invention the audio-signal stored at the data carrier should be almost completely preprocessed with respect to the mixing and sound-engineering.

20 It should be noted that it is known to present music in different formats at the same data carrier, e.g. stereo, five channel audio, Dolby Surround ,etc.. Each format is typically mixed separately, and anyway, each format may hardly be transformed into another rendering system.

25 But, according to the invention, a music mix may be released once and for all e.g. on a DVD, and if another rendering format is desired later, the rendering system may be re-configured without any need for manipulating the origin data source.

When, as stated in claim 24, the directional channels are established independently of  
30 a subsequent rendering, a further advantageous embodiment of the invention has been obtained

The directional components are established independently of the subsequent rendering of the audio channels.

5 When, as stated in claim 25, the number of directional channels are at least eight, preferably at least twenty, a further advantageous embodiment of the invention has been obtained.

10 When, as stated in claim 26, at least two of the directional channels are uncorrelated, a further advantageous embodiment of the invention has been obtained.

When, as stated in claim 27, at least two of the directional channel are stored at the data carrier in a compressed state, a further advantageous embodiment of the invention has been obtained.

15 If desired, the effective necessary bandwidth of the complete signal represented in the format according to the invention may be reduced taken into consideration that many audio direction components are typically un-occupied in periods. Such un-occupied channel components will typically increase when increasing the number of channels.

20 A possible compression may e.g. be applied according to PCT applicaiton WO 97/38493 by Philips.



## The figures

The invention will be described below with reference to the drawings of which

- 5    fig. 1            shows the basic understanding of a reverberated sound
- fig. 2            shows the basic principles of a sound processing device according to  
                         the invention
- fig. 3a-3c        shows different sub-portions of the system according to the invention,
- fig. 4a-4b        illustrates early pattern generators according to the invention
- 10   fig. 5            shows a two-dimensional system of co-ordinates for illustrative  
                         purposes,
- fig. 6a-6b        shows two embodiments of an audio signal format according to the  
                         invention,
- fig. 7            shows a three dimensional system of co-ordinates with two additional  
15                    planes,
- fig. 8            shows the angle of the elevation of the additional planes shown in fig.  
                         7,
- fig. 9            shows another embodiment of an audio signal format according to the  
                         invention,
- 20   fig. 10a-10c      shows fig. 9 divided into sub-planes for the readers convenience,
- fig. 11            shows an audio signal processing method according to the invention,
- fig. 12            shows the same as fig 11, but illustrated in an alternative manner,
- fig. 13            shows a processing system according to a further embodiment of the  
                         invention,
- 25   fig. 14            shows a recording, distribution and/or reproducing system according to  
                         a still further aspect of the invention,
- fig. 15            shows a recording, distribution and/or reproducing system as illustrated  
                         in fig. 14, but showing a storing medium for the pre-processed signal  
                         and the generation of the input signals,
- 30   fig. 16            shows a additional embodiment of the system illustrated in fig. 14, and
- fig. 17            shows different modules of a rendering system according to the  
                         invention.

### Detailed description

According to most embodiments of the invention, it is the general approach that artificial generation of room simulated sound should comprise an early reflection pattern and a late sound sequence, i.e. a tail sound signal.

It should be noted that the invention is basically directed at the early reflection patterns, and consequently sound processing based on early reflections patterns within the scope of the invention.

Fig. 1 illustrates the basic principles of a conventional signal processing unit.

The circuit comprises an input 1 communicating with an initial pattern generator 2 and a subsequent reverberation generator 3. In addition, the initial pattern generator 2 and the subsequent reverberation generator 3 are connected to two mixers 4, 5 having output channels 6 and 7, respectively.

The initial pattern generator 2 generates an initial sound sequence with relatively few signal reflections characterising the first part of the desired emulated sound. It is a basic assumption that the initial pattern is very important as a listener establishes a subjective understanding of the simulated room on the basis of even a short initial pattern.

An explanation of this performance is that this signal reception corresponds to the actual sound propagation and reflection in a real life room.

Hence, reflections in a certain room will initially comprise relatively few reflections, as the first sound reflection, also called first order reflections, have to propagate from a sound source at a given position in the room to the listener's position via the nearest reflecting walls or surfaces. Compared with the overall heavy complexity of the

technique, this sound field will be relatively simple and may therefore be emulated in dependency of the room and the position of the source and the listener.

Subsequently, and of course with some degree of overlapping, the next reflections  
5 will appear at the listeners position. These reflections, also called second order reflections, will be the sound waves transmitted to the position of the receiver via two reflecting surfaces.

Gradually, this sound propagation will increase in dependency of the room type, and  
10 finally the last reflected sound will be of a more diffuse nature as it comprises several reflections of several different orders at different times.

Apparently, the sound propagation will gradually result in a diffuse sound field and the sound field will more or less become a "sound soup". This diffuse sound field  
15 will be referred to as the tail sound.

If the walls have high absorption coefficients, the propagation will decrease quite fast after a short time period of time while the sound propagation will continue over a relatively long period of time if the absorption coefficients are low.

20

Fig. 2 illustrates the basic principles of a preferred embodiment of the invention.

For reasons of explaining, the shown embodiment of the invention has been divided into three modules 20A, 20B and 20C.

25

The first module 20A of the room simulator, according the embodiment shown, comprises M source inputs 21, 22, 23.

The source inputs 21, 22 and 23 are each connected to an early pattern generator 26,  
30 27 and 28.

Each early pattern generator 26, 27 and 28 outputs M directional signals to a summing unit 29. The summing unit adds the signal components of each of the N predetermined directions from each of the early pattern generators 26, 27 and 27.

- 5 The summing unit output N directional signals to the module 20B comprising direction rendering unit 201.

The basic establishing of the N directional signals has been illustrated in fig. 3a.

- 10 Now returning to fig. 2, the direction rendering unit converts the N directional signal to a P channel signal representation.

The basic establishing of the P channels of module 20B has been illustrated in fig. 3b.

15

Moreover, the system comprises a third module 20C. The module 20C comprises a reverb feed matrix 202 fed by the M source inputs 21, 22, 23. The reverb feed matrix 202 outputs P channel signals to a reverberator 203 which, in turn, outputs a P channel signal to a summing unit 204.

20

Thus, the summing unit 204 adds the P channel output of the reverberator 203 to the output of the direction rendering unit 201 and feeds the P channel signal to an output.

The basic establishing of the P channels of module 20C has been illustrated in fig.

25 3c.

Before explaining the overall functioning of the algorithm, the basic functioning of the early pattern generators 26, 27, 28 and the summing unit 29 will be explained with reference to fig. 3a

30

According to fig. 3a, the module 20A comprises a number of inputs S1, S2, S3 and S4.

It should be noted that a number of four inputs have been chosen for the purpose of obtaining a relatively simple explanation of the basic principles of the invention. Many other input numbers may be applicable.

5

Each of the inputs are directed to an early pattern generator 26, 27 and 28. Each early pattern generator generates a processed signal specifically established and chosen for the source input S1, S2, S3 and S4. The processed signals, according to the shown embodiment, are established as a signal composed of seven signal components d1, d2, d3, d4, d5, d6 and d7. The seven signal components represent a directional signal representation of the established sound and the established signal contains both the direct sound and the initial reverberation sound.

10

A possible embodiment of the invention implies a five channel rendering of 10-  
directional signal where the directions of the input signal format are 0, +/-15, +/-30,  
+/-70, +/-110 and 180 degrees, and the intended location of the five corresponding  
loudspeakers are 0, +/-30 and +/-110 degrees according to ITU 775.

15

Obviously, several other directions and locations may be applicable. A preferred embodiment comprises more than 20 directions.

20

Accordingly, each of the inputs S1, S2, S3 and S4 may refer to mutually different locations of the input source to which the early pattern is generated.

Successively, the signals from each source are summed in summing unit 29. The summing is carried out as a simple adding of each signal component, i.e.

25

$d1:=d1(S1)+d1(S2)+d1(S3)+d1(S4)$ ,  $d2:=d2(S1)+d2(S2)+d2(S3)+d2(S4)$ ,  
 $d3:=d3(S1)+d3(S2)+d3(S3)+d3(S4)$ ,  $d4:=d4(S1)+d4(S2)+d4(S3)+d4(S4)$ ,  
 $d5:=d5(S1)+d5(S2)+d5(S3)+d5(S4)$ ,  $d6:=d6(S1)+d6(S2)+d6(S3)+d6(S4)$  and  
 $d7:=d7(S1)+d7(S2)+d7(S3)+d7(S4)$ .

30

It should be noted that, even though undesired, according to the preferred embodiment of the invention, the signals  $d_1, \dots, d_7$  may comprise tail sound components or even whole tail-sound. It should nevertheless be emphasised that according to the preferred embodiment of the invention such tail sound may advantageously be generated according to a relatively simple panning algorithm and subsequently added to the established summed initial sound signal as the established summed initial sound comprises the dominating room determining effects.

Moreover, it should be emphasised that a separate tuning of the resulting tail-sound signal is much easier when made separately from the individual tuning of the different source generators.

Turning now to module 20B, fig. 3b illustrates the basic functioning of the direction rendering unit 201.

According to the shown embodiment of the invention, the seven directional signal outputs from module 20A are mapped into a chosen multi-channel representation. According to the illustrated embodiment, the seven directional signals are mapped to a  $P=5$  channel output.

According to a preferred embodiment of the invention, the type of multi-channel representation is a selectable parameter, both with respect to number of applied channels and to the type of speaker setup and the individual speaker characteristics.

The conversion into a given desired  $P$  channel representation may be effected in several different ways such as implying HRTF based (head related transfer function), a technique mentioned as Ambisonics, VBAP (vector based amplitude panning) or a pure experience based subjective mapping.

Turning now to fig. 3c module 20C is illustrated as having an input from each of the source inputs  $S_1, S_2, S_3$  and  $S_4$ . The signals are fed to a reverb feed matrix 202 having five outputs, corresponding to the chosen channel number of the direction render-

ing unit 201. The five channel outputs are fed to a reverberation unit 203 providing a five channel output of subsequent reverberation signals.

The reverb feed matrix 202 comprises relatively simple signal pre-processing means  
 5 (not shown) setting the gain, delay and phase of each input's contribution to each reverb signal and may also comprise filtering pre-processing means.

Subsequently, the reverberation unit 203 establishes the desired diffuse tail sound signal by means of five tank circuits (not shown) and outputs the resulting sound  
 10 signal to be added to the already established space processed initial sound signal. According to the illustrated preferred embodiment of the invention, the tail sound generating means are added using almost no space processing due to the fact that a space processing of the tail sound signal according to the diffuse nature of the signal has little or no effect at all. Consequently, the complexity of the overall algorithm  
 15 may be reduced when adding the tail sound separately and making the tuning much easier.

Moreover, it should be noted that the above mentioned separate generation of the tail-sound provides a more natural diffuse tail-sound due to the fact that the distinct  
 20 comb-filter effect of the early pattern generator should preferably only be applied to the initial pattern in order to provide naturalness.

It should be noted that the above generation of subsequent reverberation signals, according to the present preferred embodiment, is generated independently of the initial  
 25 sound generation. Nevertheless, it should be emphasised that the invention is in no way restricted to a narrow interpretation of the basic generation of a reverberation sound. Thus, within the scope of the invention, both the initial sound and the sound tail of each sound may of course be located within an artificial room and subsequently summed in a summing unit.

30

Turning now to fig. 4a, an early pattern generator, such as 26 of fig. 2, is illustrated in detail. The early pattern generator is one of four according to the above described

illustrative embodiment of fig. 2, and each generator comprises a dedicated source input S1, S2, S3 and S4.

The shown early pattern generator 26 comprises a source input S1.

5

According to the shown embodiment, the source input is connected to a matrix of signal processing means. The shown matrix basically comprises three rows of signal processing lines, which are processed by shared diffusers 41, 42.

10 Accordingly, the upper row is fed directly from the input S1, the second row is fed through the diffuser 41, and the third row is fed through both diffusers 41 and 42.

Each row of the signal processing circuit comprises colour filters 411, 412, 413; 421, 422, 423; 431, 432, 433. According to the shown embodiment, colour filters of the  
15 same columns are identical, i.e. colour filter 411=421=431.

It should nevertheless be emphasised that the colour filters may of course differ within the scope of the invention.

20 Moreover each row comprises delay lines 4111, 4121 and 4131 which are serially connected to the colour filters 411, 412, 413. Finally, each column may be tapped via level and phase controllers such as 4000, 4001 and 4002. It should be noted that each level-phase controller 4000, 4001 and 4002 are tap specific.

25 Hence, the initial pattern generator 26 comprises a matrix which may comprise several sets of predefined presets by which a certain desired room may be emulated.

As already mentioned and according to the simplified embodiment of the invention, signals of the current predefined room emulation are tapped to the directional signal  
30 representation of the present sound source S1. According to the illustrated programming, four signal lines are tapped to seven directional signal components. One signal,



N13 of row 1, column 3, is fed to sound component 1, one signal, N21, is fed to signal component 3, and two signals, N11 and N22 are added to the sound component 4.

5 It should be noted that each tapped signal has consequently been processed through one of three combinations of diffusers, one of three types of predefined colour filters EQ, a freely chosen length of delay line and a freely chosen level and phase output.

Obviously, several other combinations and number processing elements are applicable within the scope of the invention.

10 According to one of the preferred embodiment of the invention, a separate row with a level-phase controller 4002 should be tapped and determine the direct sound. When integrating the direct sound into the early pattern generation, the location of both the direct sound as well as the corresponding EPG and reverberation sound signals may  
15 be mapped into the sound signal representation completely similar to the desired directionality irrespective of directional resolution and complexity.

Evidently, the directional signal representation components usually comprise signals fed to each component 1-7 and not only the illustrated three.

20 It should be noted, that the chosen topology of the early pattern generator within the scope of the invention may be chosen from a set of more or less equivalent topologies. Moreover, the signal modifying components may be varied, if e.g. a certain degree of tail-sound is added before or after tapping.

25 As the illustrated early pattern generator comprises linear systems, it will be possible to interchange the components, e.g. the colour filters EQ may be interchanged with the diffusers DIF.

30 Fig. 4b illustrates a further possible embodiment of the early pattern generator, comprising colour filters EQ placed in the feed line to each row and diffusers DIF placed in each column in each row.



vectors 920 ( $d_1 \dots d_{12}$ ) are evenly distributed around the circle 913, causing the angle 921 between two neighbor vectors to be the same, indifferently to which vector is chosen.

- 5 Incoming sounds may be defined by these vectors, the direction of the vectors representing the direction of the incoming sounds (or rather the direction, from which the incoming sound signals are coming), and a number representing the magnitude or amplitude of the incoming sound signals.
- 10 The number of vectors 920 (twelve) is only an example. It is possible to comprise any number of vectors, as long as the number of vectors is sufficient to define the incoming sound satisfactorily. A preferred embodiment would comprise more than 25 vectors or directions, for example 30, 40, 50 or even more. The higher the number of vectors, the higher resolution of direction is achieved. And the higher resolution of
- 15 direction, the more accurate source localization is achieved. For sounds coming from sources placed in front of the head, the human beings are capable of distinguishing directional differences, as small as 3 degrees. This is the so-called localization blur.

- The illustrated angle 921 between two neighbor vectors is only an example. It is
- 20 possible to comprise any principle of vector distribution around the circle, including uniform distribution and experience based, e.g. psycho-acoustic based distribution.

- Having in mind that the ears are not quite as good of directional distinguishing of sounds coming from behind the head or from the sides of the head, as they are of
- 25 sounds coming from in front of the head, it is advantageous to comprise a distribution with fewer vectors behind the head than in front of the head. This gives a less accurate localization behind the head, but the human being will normally not be able to tell the difference anyway. A preferred embodiment using this distribution principle is shown in fig. 6b.

- 30 Another distribution of the vectors 920 could be based on measures of the density of different sounds in all possible directions. The vectors could then be distributed with

small angles between them in direction sectors with high density of directional sound signals and with larger angles between them in direction sectors with low density of directional sound signals.

- 5 A further way of distributing the vectors around the circle could be based on human impressions.

Another perspective of the invention is added when the above format is defined according to a room instead of just a plane. Fig. 7 defines such a room. It is a three-  
10 dimensional system of co-ordinates, with the axes labeled 'x' 930, 'y' 931 and 'z' 932. The axes 930-932 are perpendicular to each other, that is: each axis is perpendicular to the other two. At the systems origin a head of a person 912 is placed, with the nose pointing in the same direction as the x-axis 930. Further two circles 946a and 946b have been added. These circles 946a and 946b are placed in  
15 parallel with the unit circle 933, but are displaced along the z-axis in such a way that they still have their centers at the z-axis. Furthermore the distance from the systems origin 912 to any point at the two circles 946a and 946b are exactly one unit, as the circles are placed on a sphere with its center in the systems origin. The circle 933 lying in the x-y-plane is called the middle plane circle. The circle 946a displaced  
20 along the z-axis in the positive direction is called the upper circle. The circle 946b displaced along the z-axis in the negative direction is called the lower circle.

Fig. 8 corresponds to fig. 7. It comprises the three axes 930-932 of the three-dimensional co-ordinate system. Further it comprises the unit circle 933 of the x-y-  
25 plane and the two additional circles 946a, the upper circle, and 946b, the lower circle, placed in parallel with the x-y-plane. The circles 946a and 946b are centered at the z-axis, and the distance from any point on these circles to the systems origin 912 is exactly one unit as described above. Further fig. 8 comprises two angles 951a and 951b. The angle 951a is the angle between the x-axis and the direction from the  
30 systems origin 912 to a point at the circle 946a lying exactly above the x-axis. The angle 951b is defined the same way, yet according to the circle 946b. This way the angles 951a, 951b indicates the displacement of the circles 946a, 946b.

Fig. 9 shows an embodiment of an audio format comprising three dimensions. It comprises the elements of figure 8. Further it comprises a number of vectors 920, pointing from the systems origin 912 to the middle circle 933. These vectors 920 are comparative to the vectors of the two dimensional audio format of figure 8a.

Further fig. 9 comprises a number of vectors 960a pointing from the systems origin 912 to the upper circle 946a and a number of vectors 960b pointing from the systems origin 912 to the lower circle 946b.

10

To be able to distinguish the vectors of these three vector systems, the three circles are drawn separately in fig. 10a-10c.

Fig. 10a shows the upper circle 946a and its corresponding vectors 960a of the three dimensional directional audio format. The angle 951a indicates the displacement of the upper circle from the x-y-plane. In addition to these already mentioned elements, fig. 10a comprises an angle 971a. It indicates the rotation of a vector 960a from the direction of the x-axis 930, with axis of rotation at the z-axis 932.

Fig. 10b shows the middle circle 933 and its corresponding vectors 920 of the three dimensional directional audio format. The angle 921 indicates the angular distance between two vectors 920.

Fig. 10c shows the lower circle 946b and its corresponding vectors 960b of the three dimensional directional audio format. The angle 951b indicates the displacement of the lower circle from the x-y-plane. The angle 971b indicates the rotation of a vector 960b from the direction of the x-axis 930.

Drawn in the same co-ordinate system, fig. 10a-10c will end up as fig. 9.

30

With reasons as those for the two dimensional audio format, the number of vectors corresponding to each circle and the number of circles are only examples, and any number of vectors and circles are within the scope of the invention.

- 5 As a human being are more capable of directional distinguishing of sources in a horizontal plane than in a vertical plane, it is not necessary to have the same resolution of vectors up- and downwards as it is sideways. This makes a preferred number of horizontal circles 5. These comprise from the top a second upper circle, a first upper circle, a middle circle, a first lower circle and a second lower circle.
- 10 Common to all circles imaginable is that the distance from any point at a circle to the system origin, i.e. the head of a human being, is one unit, or in other words, the circles are all placed with their perimeters on the surface of a sphere with a radius of one unit.
- 15 A preferred embodiment would also comprise fewer vectors pointing towards each of the upper or lower planes than to the middle plane. This is because the highest resolution of vectors wanted and also usable to the human being is in the middle plane.
- 20 In a further preferred embodiment an upper circle and/or a lower circle is situated near respectively the positive part (i.e. the angle 951a being close to 90°) and the negative part (i.e. the angle 951b being close to 90°) of the z-axis and contains only few vectors. Such upper and/or lower circles could even be defined as points on the z-axis, whereby only one vector would correspond to these upper and/or lower
- 25 "circles", that is a vector located along the positive direction of the z-axis and/or a vector located along the negative direction of the z-axis.

- In an advantageous simple embodiment of the invention the audio format could be defined by a middle circle as described above in combination with a vector along
- 30 the positive part of the z-axis and optionally a vector along the negative part of the z-axis.

The distribution of vectors around a circle is also just an example. As explained for the two-dimensional audio format many distribution principles are imaginable and applicable and hence within the scope of this invention. This could be a uniform distribution principle as shown in the drawings 9, 10a-10c, an experience based  
 5 distribution principle, a distribution principle based on measures of the localization blur in different directions as shown for the two-dimensional system in fig. 6b or a distribution principle based on measures of the portion of sound gradients in different areas for a specific room and situation.

10 Further it shall be pointed out that the vectors could be placed in other manners than with their ends placed at a circle, especially the vectors, which are placed with an angle in relation to the x-y-plane. The angle 951a or 951 (fig. 8) in relation to the x-y-plane could vary as a function of the angle 921 (fig. 6a) if found appropriate, whereby the ends of the vectors could be situated on for example non-circular curves  
 15 on the surface of the unit sphere.

In fig. 11 and 12 is illustrated signal processing methods and systems, which utilize the above-described audio signal formatting system.

20 A number of signals, preferably audio signals,  $s_1 - s_M$  are provided in the signal format according to the invention, e.g. comprising  $N$  directional components according to the same directional format. It shall be noted that not all of these components actually need to contain any signal, as the signal format must be expected to comprise a relatively large number of directional components in order to be able to represent the involved signal sources satisfactorily. Thus some (or even a large number) of  
 25 the components of the actual signal sources may be zero.

The audio signals  $s_1 - s_M$  may be recordings of or (microphone) signals stemming from single musical instruments, group of instruments, singers etc. or the signals  $s_1 -$   
 30  $s_M$  may be other forms of signals, which will have to be combined to represent a resulting audio signal or other forms of signals.

30 The basic functioning of the direction rendering unit (DRU) will thus be to map the  
N directional signal outputs 973 and 983 from units 972 or 982 into a chosen multi-  
channel representation, according to the available speaker set-up.



The conversion into a given desired P channel representation may be effected in several different ways such as implying HRTF based (head related transfer function), a technique mentioned as Ambisonics, VBAP (vector based amplitude panning) or a  
5 pure experience based subjective mapping.

Fig. 13 shows a system according to a further aspect of the multi-channel audio format and processing method of this invention. It shows a model of a reverberation unit. Here a number of units 9101a-9101c, called room simulator units, calculate how  
10 the sound emitted from a source 9100a-9100c will be heard at the listener's position, including reflections from the room. These room simulator units may for example be early pattern generators, EPG's, which will be assumed to be the case in the following. As output each EPG 9101a-9101c has the same listener placed at the same location, but as input the EPG's could have different instruments 9100a-9100c  
15 placed at different locations. To make the best room-simulation, the EPGs should calculate the resulting sound from as many directions as possible, and this result 9102a-9102c could then be sent on in the audio format of this invention. The result of each EPG should in any suitable way be added to form the final sound heard at the listener's position, and this addition could be made according to the audio signal  
20 processing method 9103 of this invention. The result 9104 from passing the outputs from the EPGs through the processing method, would be in the multi-channel audio format of this invention. Finally the sound in each direction of this format would have to be mapped to the available loudspeakers 9106a-9106b or channels chosen by the user. This mapping is performed by a direction rendering unit (DRU) 9105.

25 Instead of just representing the sound coming from a particular direction, each vector could represent the method of calculating the sound coming from that particular direction. In this embodiment each vector would comprise a listing of partial sound signals as a function of time and as a function of the actual input signals. In each  
30 vector shall then the partial sound signals be summed.

Fig. 14 illustrates a recording, distribution and/or reproducing system according to a  
5 further aspect of the invention, said system utilizing the signal format according to  
the first aspect of the invention.

In the pre-processing unit (PPM) 9111 a processing of the input source signals  $s_1 - s_M$  takes place. This pre-processing may in a simple form be a summing of the corresponding directional components of each input source signal, e.g.

25

30

Other forms of signal processing may be incorporated in the pre-processing unit (PPM) 9111, such as equalizing, coloring, addition of tail sound signals,



for example in the form of a decoder, for transforming the T-channel signal IF into a signal containing a suitable number of channels, which may be reproduced by the end-user equipment.

- 5 The user processing means UPM may be predestined to transform the received signal from a certain number of channels T to a certain number of channels to be reproduced by the end-user equipment. Alternatively, the user processing means UPM may be configured to determine the number of channels T incorporated in the received signal IF and to perform a transformation from this number of channels to a certain number of channels to be reproduced by the end-user equipment. Further, the user processing means UPM may be able to perform a transformation to one of two or more different reproducing systems UF1 - UFk, containing a different number of channels, in dependence upon an active choice by the user or in dependence upon other factors, such as parameters of the received signal IF.

15

- As illustrated, the user processing means UPM of fig. 14 is configured to reproduce the audio input signals in a specific reproducing system labeled UF3, which may be any type of the relatively large number of reproducing systems (labeled UF1 - UFk on fig 14), which are available at present, and which may reproduce the signals via loudspeaker systems using stereo systems, 3-, 4- or 5-channel systems and/or user-specified set-ups etc.

- In addition to the means for transforming the number of channels, the user processing means UPM may further comprise other means for processing the received signal IF, for example means for equalizing, other means for coloring the signals, delaying means, adding reverberation, dynamic processing etc. These further processing steps may be designated in relation to the actual type and character of the user reproducing equipment, e.g. in order to achieve an optimal sound reproduction.

- 30 The transformation of the number of channels T contained in the received signal IF to the number of channels, which may be reproduced by the actual end-user equipment, may be performed using linear transformation of the received signal-

As indicated in fig. 15, the input signals s1 – sM may originate from microphones or similar transducers producing electric signals 9110a – 9110M. These signals are processed by signal processing means 9114a – 9114M, whereby the signals s1 – sM each having N signal components according to the signal format of the invention is produced. The signal processing means 9114a – 9114M may for example be room simulators, early pattern generators etc. Some or all of the input signals for these signal processing means or for the pre-processing means PPM 9111 may also have been produced artificially, for example by electronic music instruments or signal generators.

25 The output signal IF from the pre-processing unit (PPM) 9111 may also be stored on  
any suitable storing media (not shown in fig. 16) or may otherwise be transmitted or  
distributed.

It will be understood that the intermediate processing may be performed by or for a  
30 record company, a record distributor, a distribution network etc. which has a need to  
distribute or may achieve an advantage by distributing signals with a fewer or a  
specific number of channels. This may thus be performed by the IPM without

influencing upon the other parts of the system, e.g. the system as shown in fig. 14 will function without regard to the system shown in fig. 15.

Fig. 17 shows different modules of a rendering system according to the invention.

5

The system comprises an independent pre-rendering stage PS.

The pre-rendering stage PS comprises a data carrier reading unit DCRU. The unit may e.g. be a DVD player adapted for reading data stored in a DVD or it may e.g. comprise a solid state memory interface.

10

The data carrier reading unit DCRU are connected to a direction rendering unit DRU by means of an M channel interface.

The direction rendering unit DRU comprises method storing means MSM and a signal processing unit SPU adapted for transforming the M-channel input into an N-channel output according to a rendering method stored in the said memory storing means MSM.

15

The direction rendering unit may e.g. perform a relatively simple mapping of the input channels into the output channels by means of a gain matrix. The rendering method may e.g. be established by means of vector based amplitude panning.

20

Moreover, the rendering unit may be adapted for exchanging the rendering method by means of software modifications.

25

The N-channel output of the pre-rendering unit DCRU are then fed to output channel connectors (OC).

The illustrated pre-rendering unit DCRU comprises only two signal output connectors. Hence, the pre-rendering unit DCRU is specifically adapted for

30

transforming the input channels into a two-channel signal representation, such as stereo.

5 The outputs of the pre-rendering unit DCRU are then fed to a traditional stereo amplifier RA connected with two loudspeakers LS.

According to the invention, the pre-rendering stage may thus be adapted for fitting to an arbitrary combination of amplifiers and loudspeakers, e.g. a surround sound system.

10 Evidently, another possible implementation of the invention would be a pre-rendering unit DCRU comprising a number of output connectors, e.g. ten. The pre-rendering unit DCRU may then, under control of the stored rendering method apply 1 to 10 physical outputs.

15 Evidently, the amplifier means may be incorporated in the pre-rendering unit DCRU within the scope of the invention.

The direction rendering unit DRU may also comprise a set of rendering methods storing the methods storing means. The rendering methods may both be different with respect to basic properties determined by the number of output channels, but it may also be different with respect to the intended positioning of the loudspeaker of the rendering system. Accordingly, the illustrated stereo rendering system may comprise e.g. twenty different predefined "stereo" variants with respect to e.g. the positioning of the loudspeakers in the room or e.g. room characteristics.

25 Such rendering may e.g. imply phase modification, equalizing, sound coloring, sound compression or the like.

7. Audio signal format according to claim 1-6, wherein the angle of the directions on one side of the common reference plane and the angle of the directions on the other side of said plane are substantially equal.
- 5 8. Audio signal format according to one or more of claims 1 - 7, wherein the said directions are distributed among all possible directions.
9. Audio signal format according to claims 1-8, wherein the said directions are distributed with a larger proportion of directions in areas with a relatively high density of sound signals than in areas with a relatively low proportion of sound signals.
- 10 10. Audio signal format according to claim 1-8, wherein the said directions are distributed with a larger proportion of directions in areas in which the human perception of sound signals is relatively sharp, e.g. in front of the head.
- 15 11. Method of representing an audio signal, wherein said signal is decomposed to a signal comprising N directional components and according to an audio signal format as characterized in one or more of claims 1 - 10.
- 20 12. Method of processing audio signals,  
  
said signals comprising  
  
M sub-signals (s1, s2, s3, ... sM),  
  
25 each of the said sub-signals (s1, s2, s3, ... sM) comprising  
  
N components (d1, d2, d3, ... dN),  
  
30 each of the said components (d1, d2, d3, ... dN) representing a direction;



**CLAIMS**

1. Audio signal format comprising  
5 N components (d1, d2, d3, ... dN),  
  
each of the said components (d1, d2, d3, ... dN) representing a direction, said components preferably being uncorrelated.  
10
2. Audio signal format according to claim 1 comprising  
  
N components (d1, d2, d3, ... dN), where N is at least 3.
- 15 3. Audio signal format according to claim 1 or 2 comprising  
  
N components (d1, d2, d3, ... dN), where N is at least 10, preferably at least 20.
4. Audio signal format according to claim 1-3, wherein the said directions are three-  
20 dimensional directions.
5. Audio signal format according to claim 1-4, wherein some or all of said directions are angled in relation to a common reference plane and where preferably all of said directions to one and the same side of the plane have been placed with approximately  
25 the same angle in relation to the common reference plane.
6. Audio signal format according to claim 1-5, wherein directions are placed on both sides of the common reference plane, where some or all of said directions are angled in relation to the common reference plane and where preferably all of said directions  
30 to one and the same side of the plane have been placed with approximately the same angle in relation to the common reference plane.

each of the said components ( $\Sigma d1, \Sigma d2, \Sigma d3, \dots \Sigma dN$ ) representing a direction,

each of the said components ( $\Sigma d_1, \Sigma d_2, \Sigma d_3, \dots \Sigma d_N$ ) being the sum of the said M sub-signals ( $s_1, s_2, s_3, \dots s_M$ ) corresponding components ( $d_1, d_2, d_3, \dots d_N$ ).

5 14. Method of representing an audio signal (AS), said method comprising the step of establishing at least two directional signal components (M), said directional signal components (M) preferably being uncorrelated.

10 15. Method of representing an audio signal according to claim 14, whereby the said audio signal is a room processed signal.

15 16. Method of combining signals established according to the method according to claim 14 and 15, whereby at least two audio signals (AS) are combined into one signal by means of an adding.

17. Method of decoding a number (M) of directional components into a, preferably lower, number (N) of directional components, said method comprising the step a transforming of the input directional components to a number N of output directional components,  
20 said input directional components representing a room simulated audio signal, said input directional components being preferably uncorrelated.

25 18. Rendering system comprising at least one input for receiving a number (M) of directional components (DC), said rendering system comprising means for transforming the input directional components into a number (N) of output channels according to at least one rendering method stored in associated storing means (MSM).

30 19. Rendering system according to claim 18, wherein one at least of the said methods implies a transforming according to a gain matrix.

20. Rendering system according to claim 18 or 19,

wherein the said method stored in the said storing means may be exchanged by means of a suitable software transmitting and/or receiving interface.

21. Rendering system according to claims 18-20,  
5 wherein the rendering system comprises a user interface adapted for selecting at least two different predefined rendering methods stored in said storing means.
22. Rendering system according to claims 18-21, wherein  
said system comprising a set of output channel (OC) connectors of which the render-  
10 ing method may define a subset of output channel connectors to be activated when applying the transforming defined by the said.
23. Multi-channel data carrier, said data carrier comprising a number (M) of audio  
channels (M), at least two of said channels representing a directional signal with re-  
15 spect to a virtual listener/reference position (VLP).
24. Multi-channel data carrier according to claim 23, wherein the directional chan-  
nels are established independently of a subsequent rendering
- 20 25. Multi-channel data carrier according to claim 23 or 24,  
wherein the number of directional channels are at least eight, preferably at least twenty.
26. Multi-channel data carrier according to claim 23-25,  
25 wherein at least two of the directional channels are uncorrelated.
27. Multi-channel data carrier according to claim 23-26,  
wherein at least two of the directional channel are stored at the data carrier in a com-  
pressed state.

**Abstract**

The invention relates to an audio signal format comprising

5     N components (d1, d2, d3, ... dN),

each of the said components (d1, d2, d3, ... dN) representing a direction.

10     According to a preferred embodiment of the invention, the components should preferably be uncorrelated to the extent that no panning is established between the signals contained in the format.

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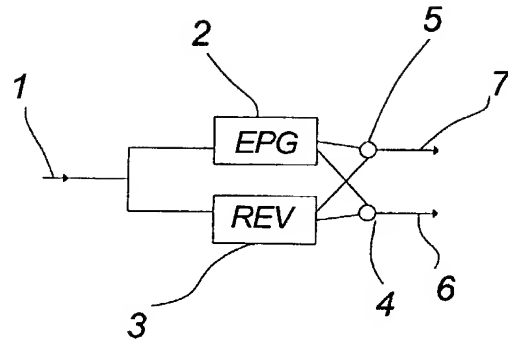


Fig.1

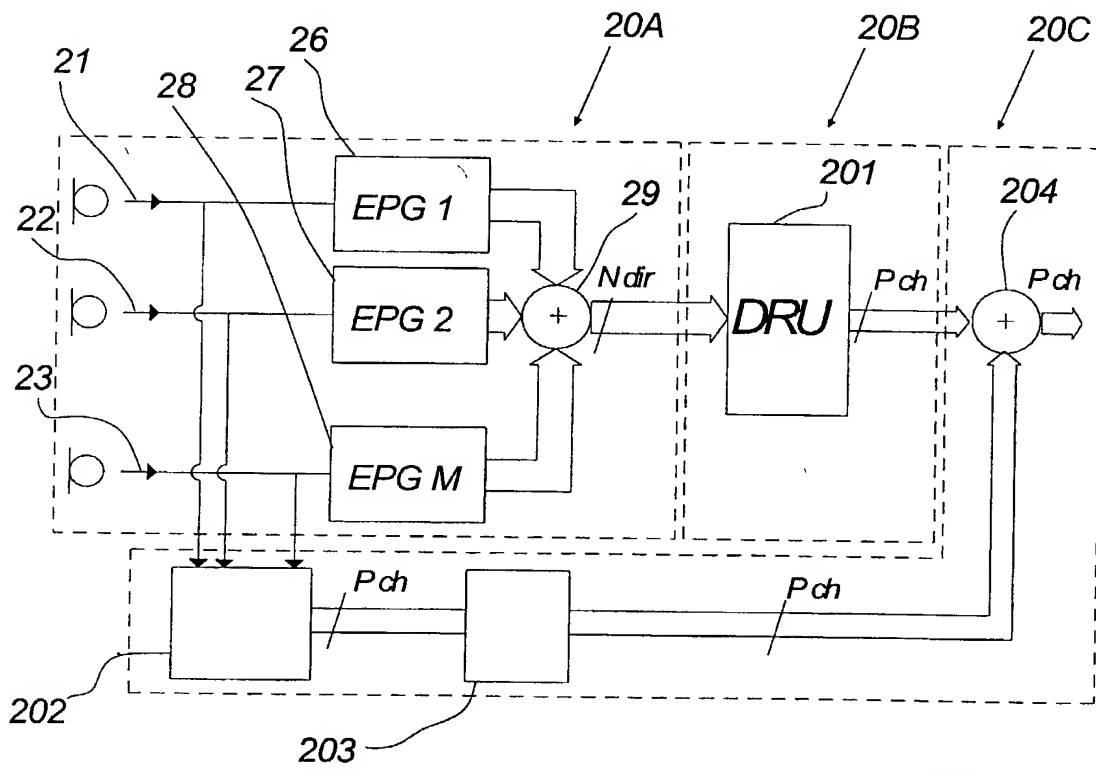


Fig.2

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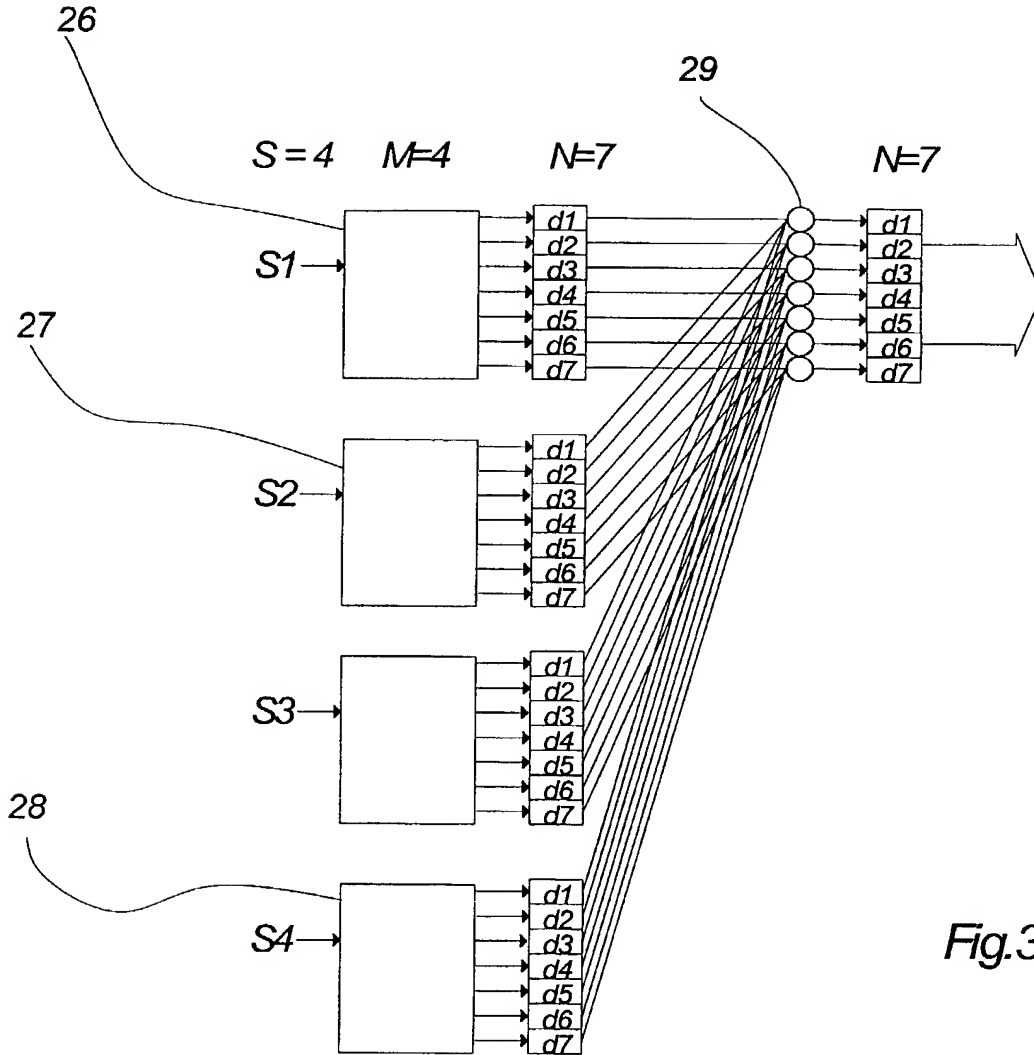


Fig.3a

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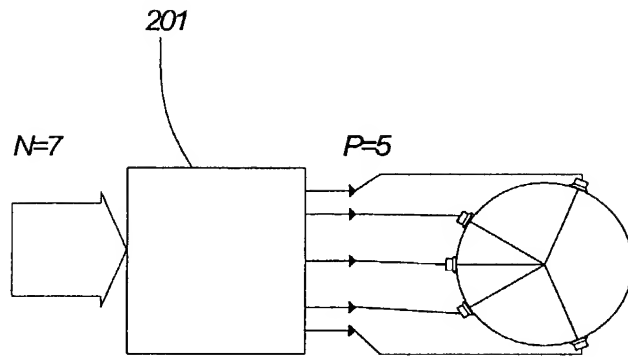


Fig. 3b

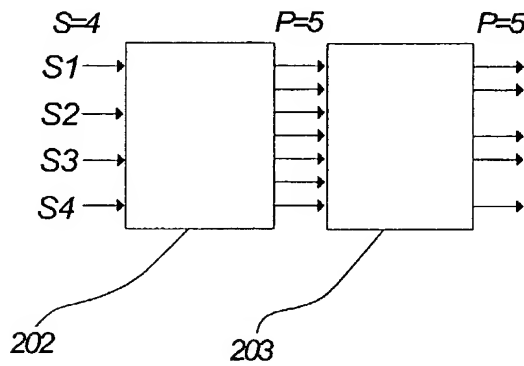


Fig. 3c



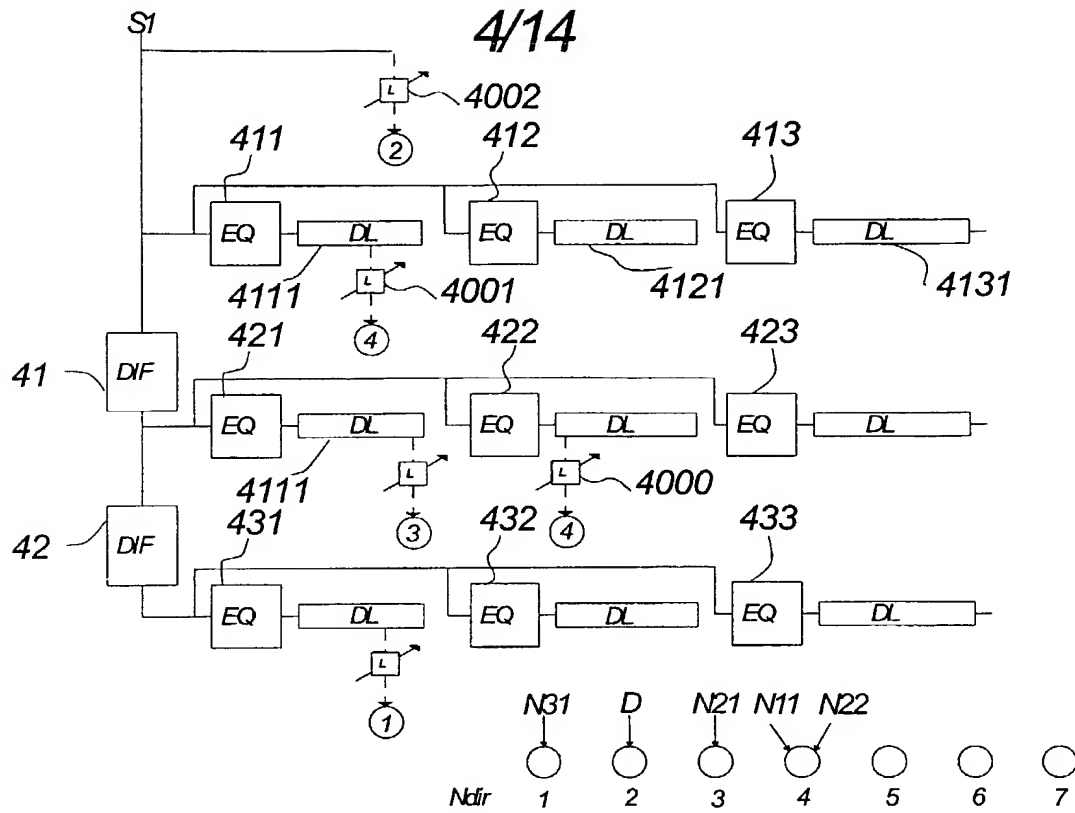


Fig.4a

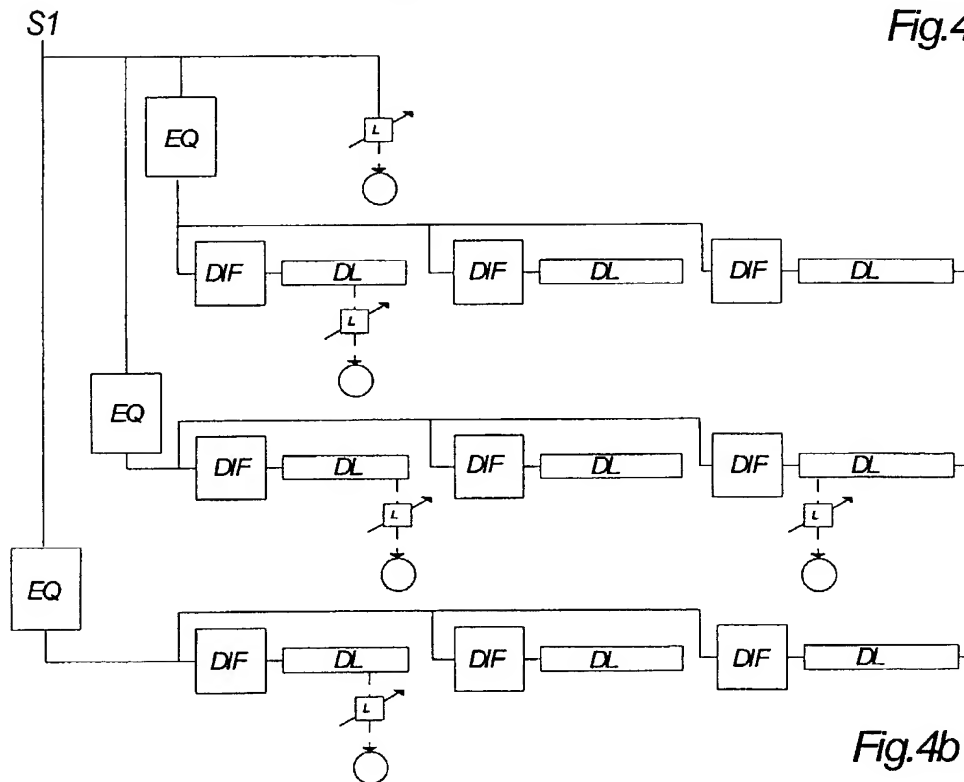
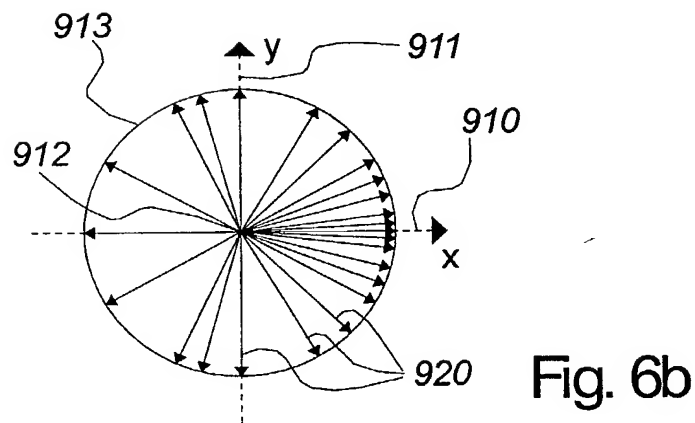
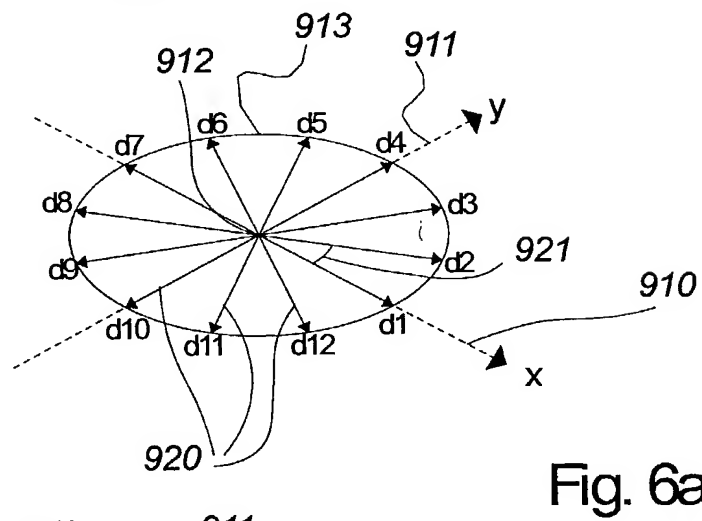
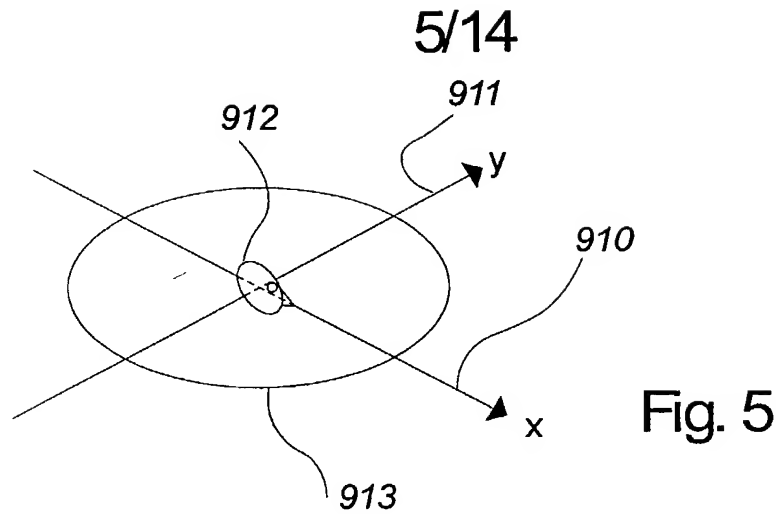
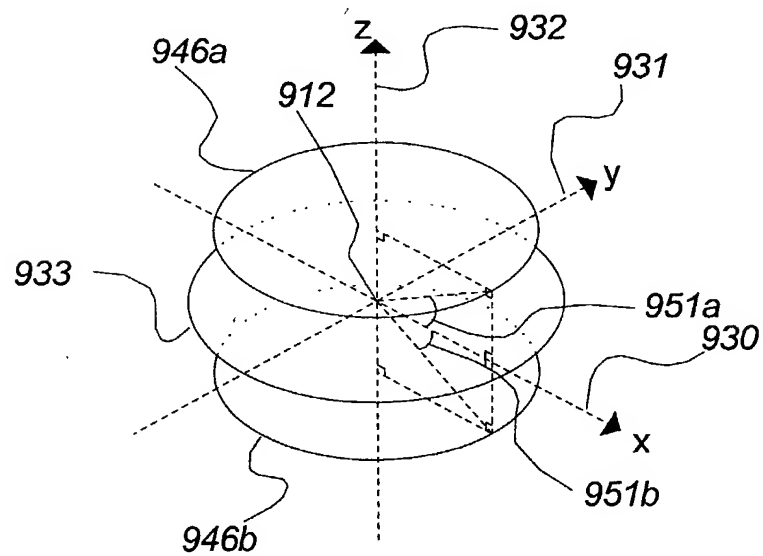
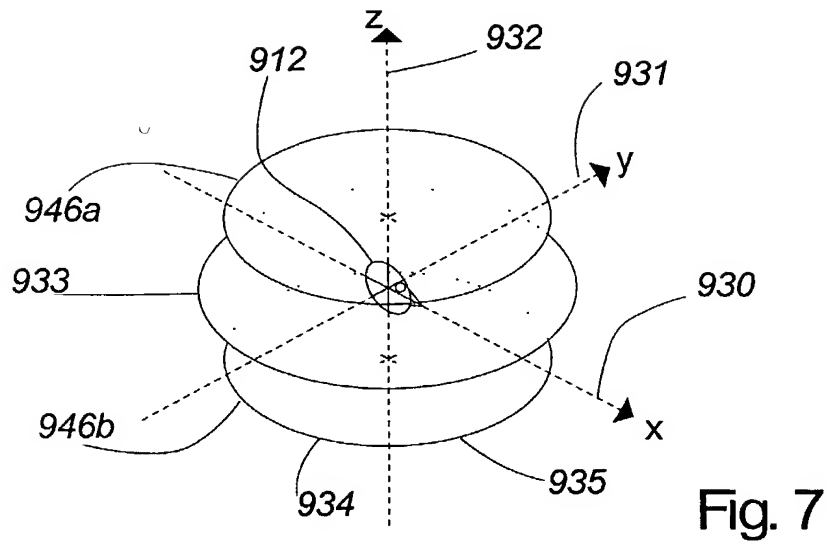


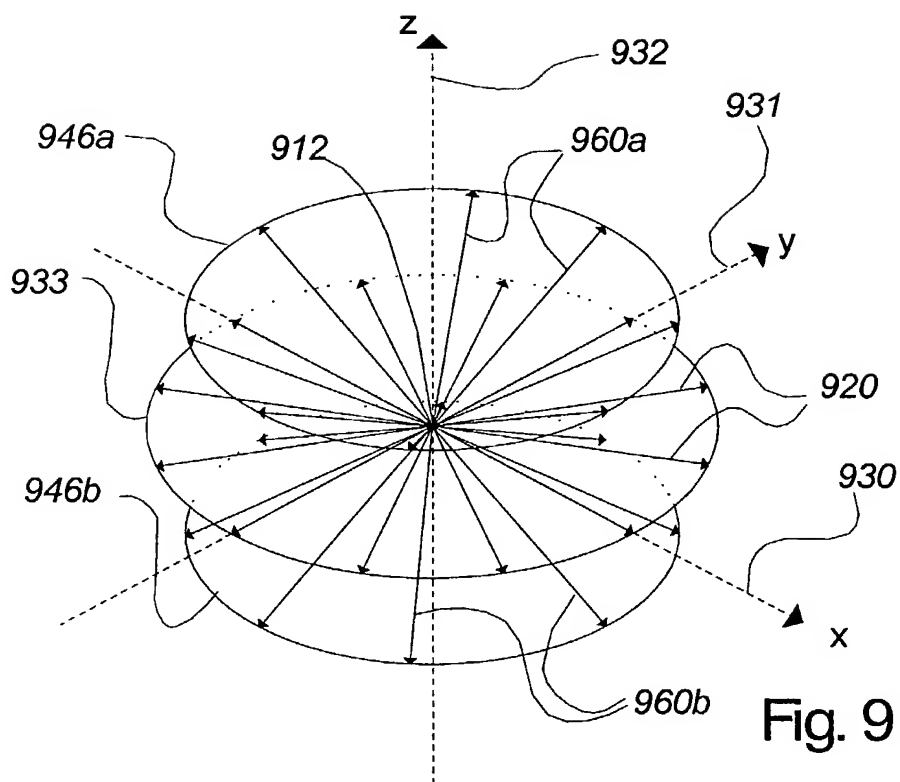
Fig.4b



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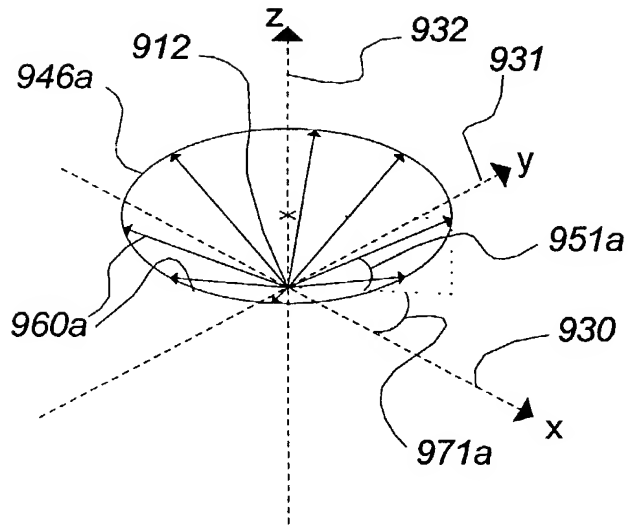


Fig. 10a

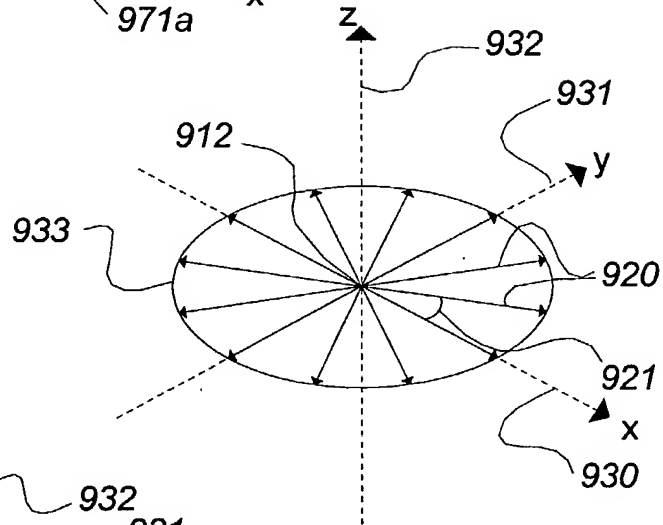


Fig. 10b

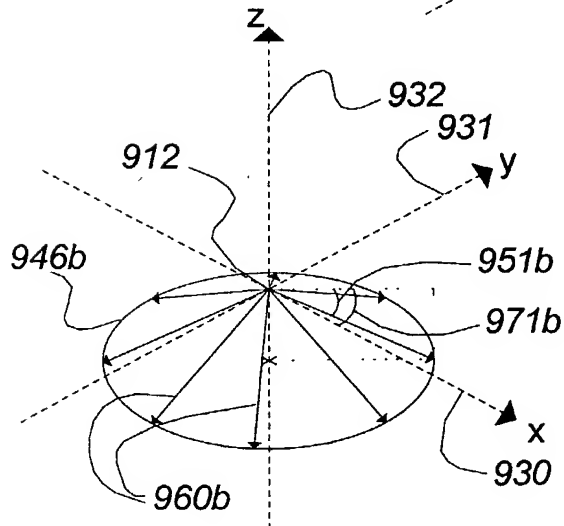


Fig. 10c

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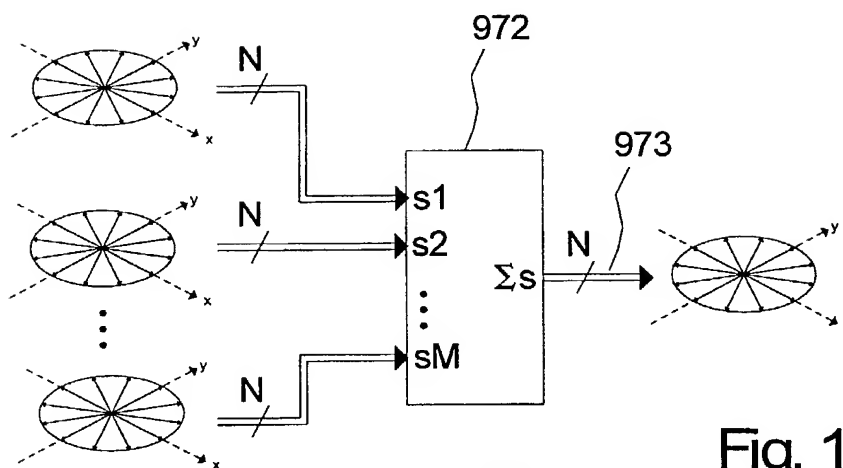


Fig. 11

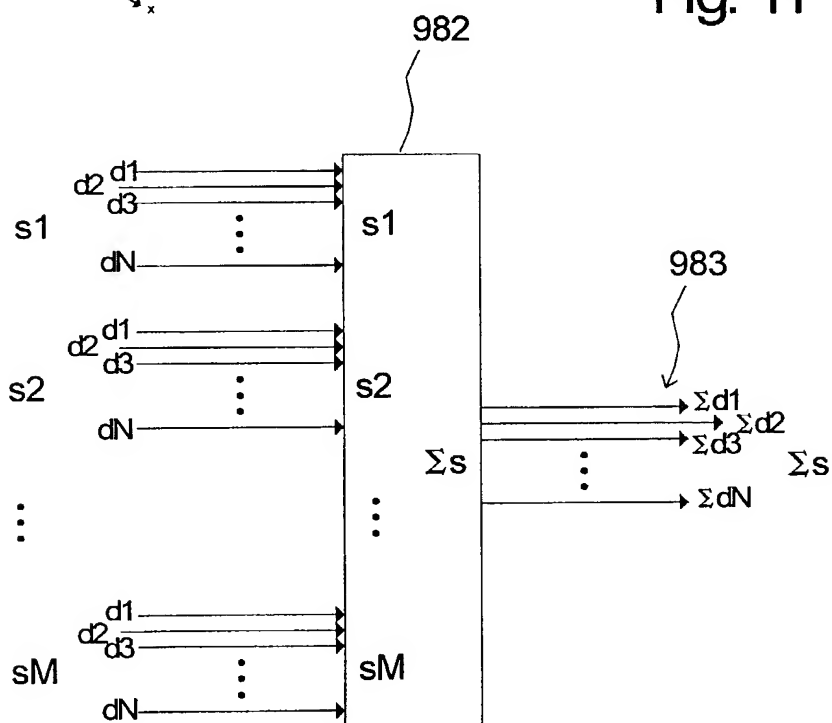


Fig. 12

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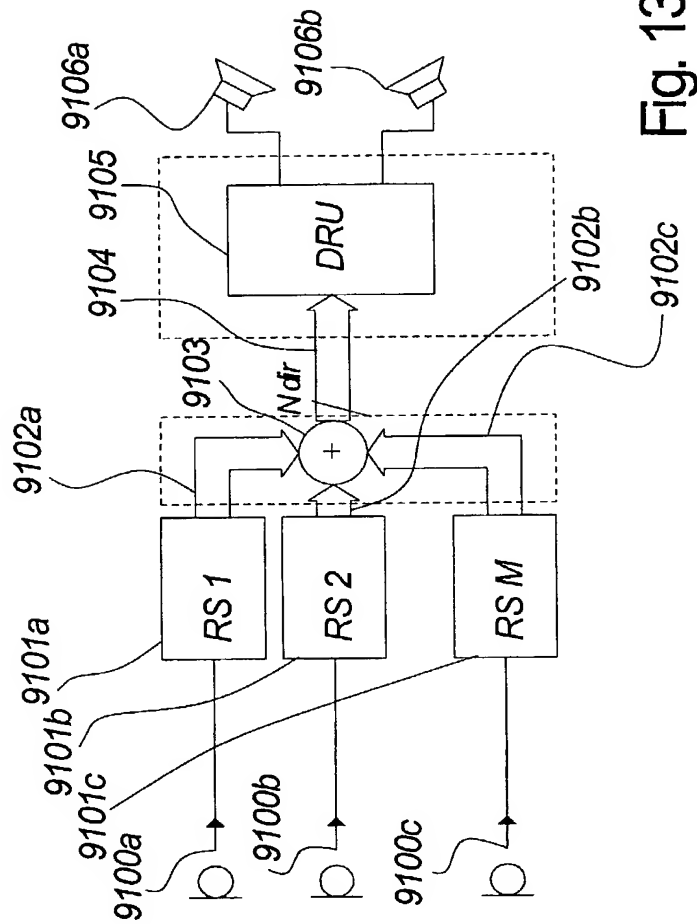


Fig. 13

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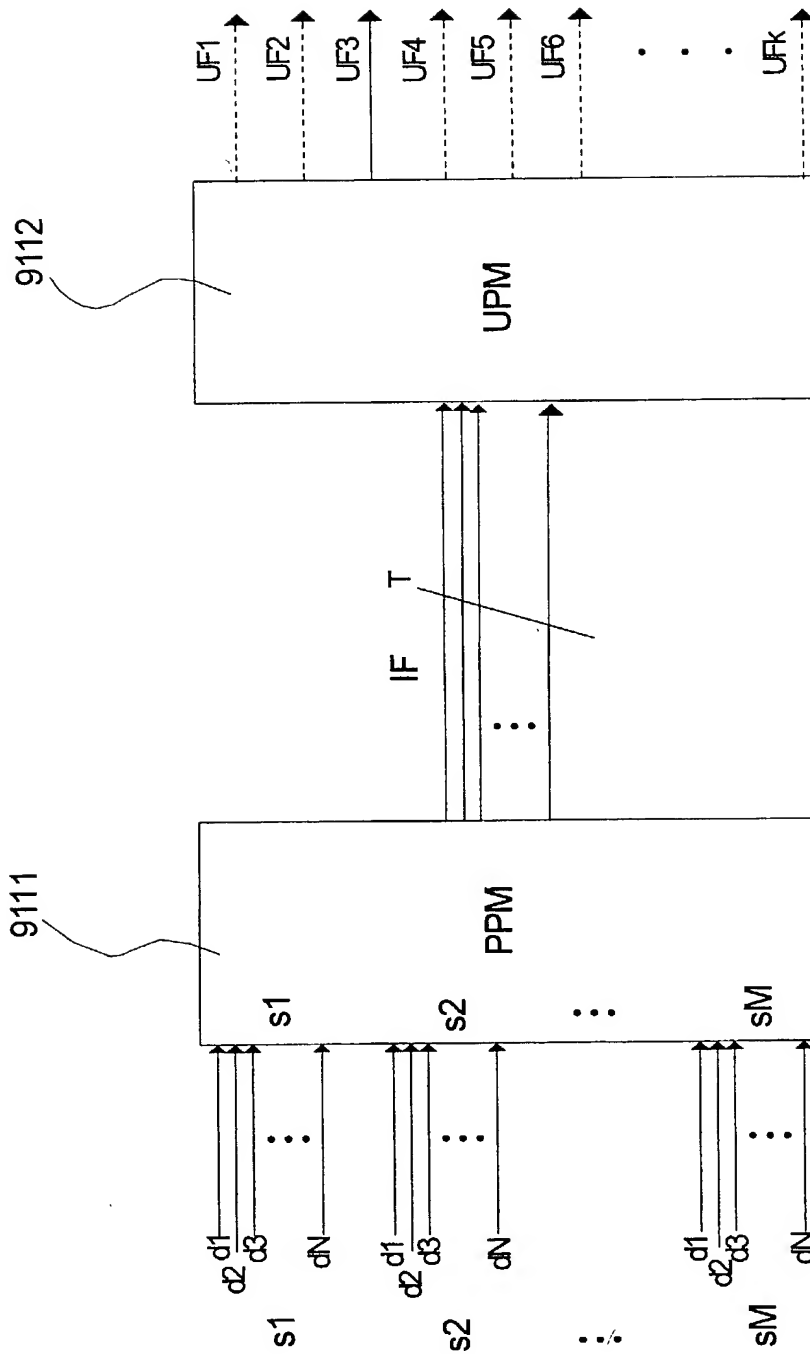


Fig. 14



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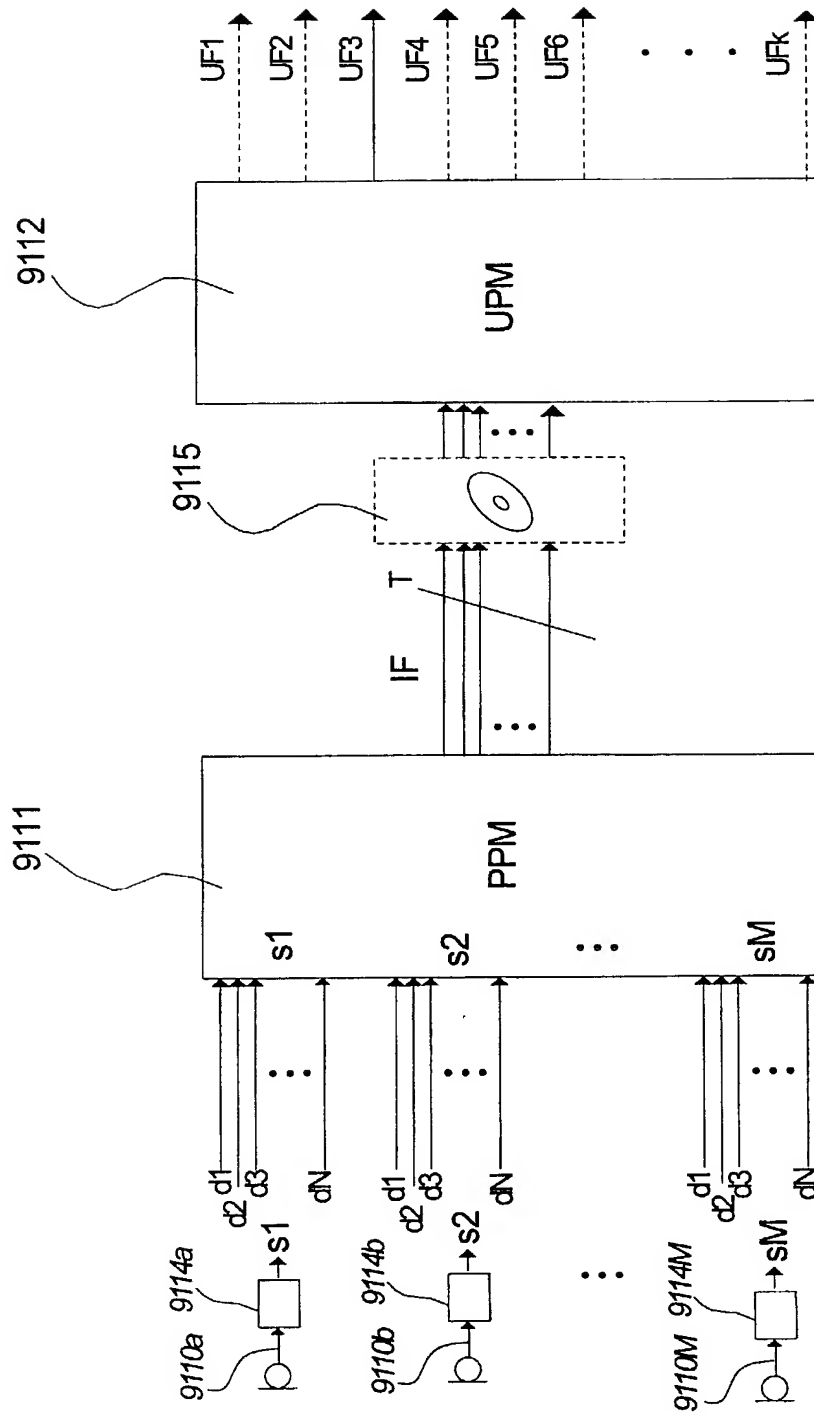


Fig. 15

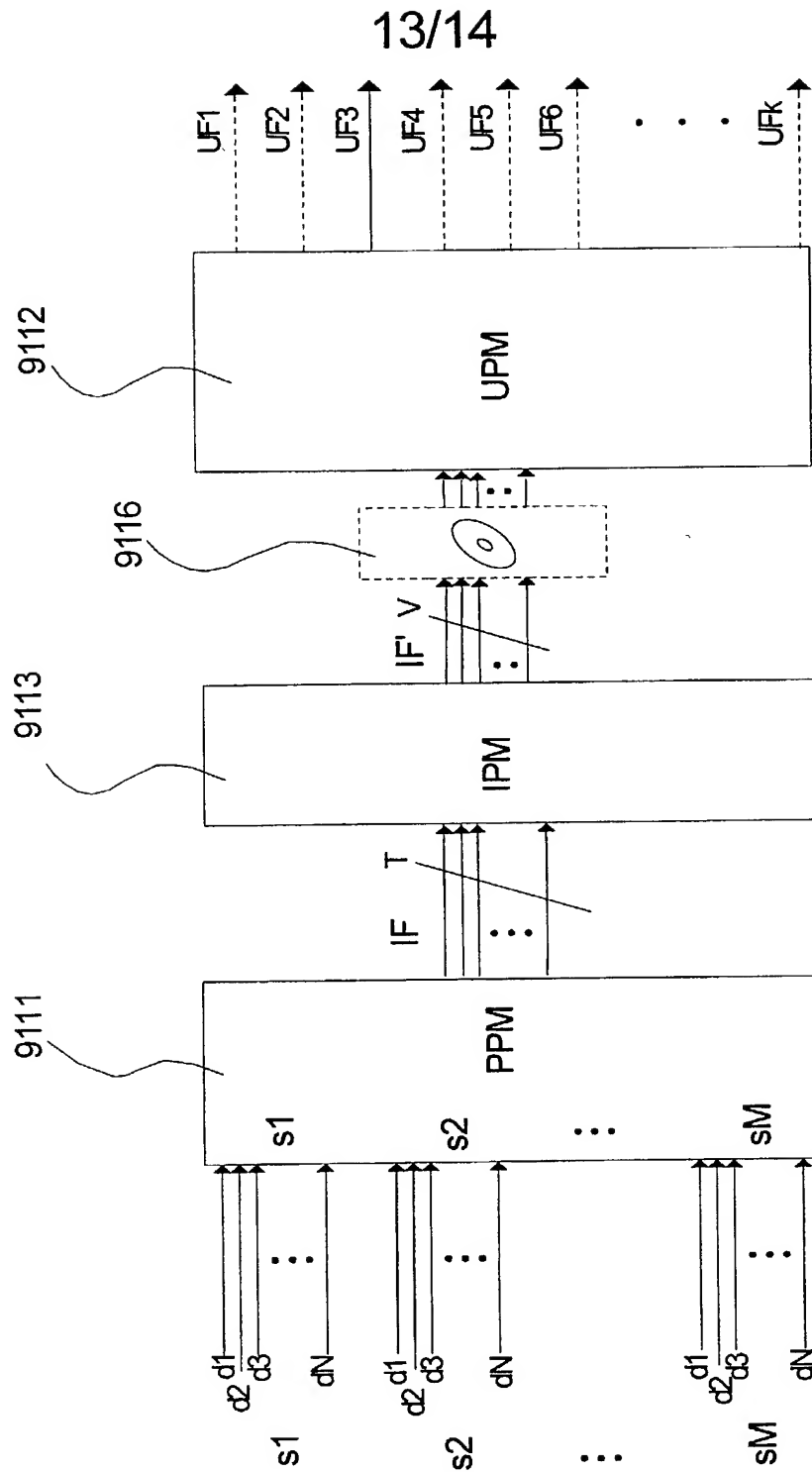


Fig. 16

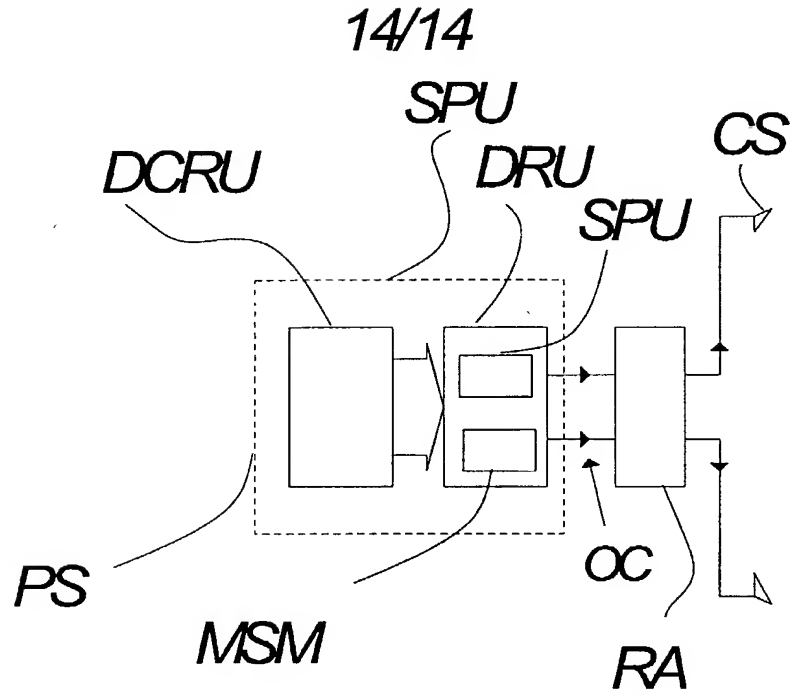


Fig.17



1004-3417 062002

## DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my/our name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled MULTI-CHANNEL PROCESSING METHOD the specification of which

(check one)

\_\_\_\_\_ is attached hereto.

☒ was filed on August 9, 2000 as

Application Serial No. PCT/DK00/00443

and was amended on February 8, 2002

(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, 1.56(a).

I hereby claim foreign priority benefits under title 35, United States Code 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s).

			Priority Claimed
<u>99202585.8</u> (Number)	<u>EPO/NL</u> (Country)	<u>9 August 1999</u> (Day/Month/Year Filed)	<input checked="" type="radio"/> Yes
<u>00201759.8</u> (Number)	<u>EPO/NL</u> (Country)	<u>18 May 2000</u> (Day/Month/Year Filed)	<input checked="" type="radio"/> Yes

Yes No

_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)
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I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

PCT/DK00/00443 _____ (Application Serial No.)	9 August 2000 _____ (Filing Date)	Pending _____ (Status) (patented, pending, abandoned)
_____ (Application Serial No.)	_____ (Filing Date)	_____ (Status) (patented, pending, abandoned)

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

PROVISIONAL APPLICATION NUMBER

FILING DATE

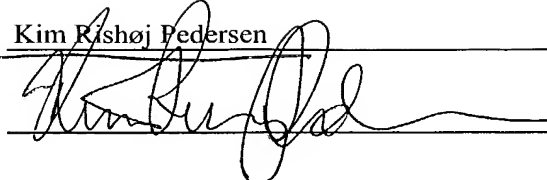



100

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or first inventor: Kim Rishøj Pedersen

Inventor's signature:



14/5/2002

Date

Residence: Egå, Denmark

DKV

Citizenship: Denmark

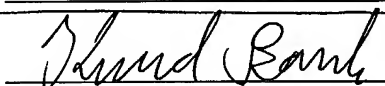
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200

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Inventor's signature:



14/5/2002

Date

Residence: Ryomgård, Denmark

DKV

Citizenship: Denmark

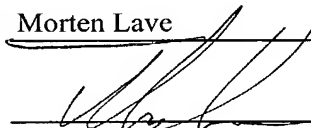
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Joint inventor, if any: \_\_\_\_\_

Inventor's signature: \_\_\_\_\_ Date \_\_\_\_\_

Residence: \_\_\_\_\_

Citizenship: \_\_\_\_\_

Post Office Address: \_\_\_\_\_